97TH CONGRESS } HOUSE OF REPRESENTATIVES { REPORT
2d Session } { No. 97-502

AUTHORIZING APPROPRIATIONS TO THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION FOR FISCAL YEAR 1983

MAY 5, 1982.—Committed to the Committee of the Whole House on the State of the Union and ordered to be printed

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Mr. FUQUA, from the Committee on Science and Technology, submitted the following

REPORT

together with

ADDITIONAL VIEWS

[To accompany H.R. 5890]

[Including cost estimate of the Congressional Budget Office]

The Committee on Science and Technology, to whom was referred the bill (H.R. 5890) to authorize appropriations to the National Aeronautics and Space Administration for research and development, construction of facilities, and research and program management, and for other purposes, having considered the same, report favorably thereon with amendments (shown in italic in the bill accompanied by this report) and recommend that the bill, as amended, do pass.

The amendments are as follows:

On page 2, line 1, strike out "$1,713,000,000" and insert "$1,706,500,000".

On page 2, line 2, strike out "$1,707,000,000" and insert "$1,699,000,000".

On page 2, line 4, strike out "$471,700,000" and insert "$463,500,000".

On page 2, line 5, strike out "$154,600,000" and insert "$177,600,000".

On page 2, line 7, strike out "$316,300,000" and insert "$330,300,000".

On page 2, line 8, strike out "$4,000,000" and insert "$9,000,000".

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On page 2, line 10, strike out "$232,000,000" and insert "$267,100,000".

On page 2, line 12, strike out "$123,000,000" and insert "$128,000,000".

On page 2, line 13, strike out "$508,900,000" and insert "$498,900,000".

On page 4, line 4, strike out "$1,178,900,000" and insert "$1,168,900,000".

On page 10, after line 5, add the following:

> (c) No monies authorized by this title shall be used to transfer to the private sector the ownership or management of any civil land remote sensing space satellite system and associated ground system equipment unless (1) the Secretary of Commerce or his designee has presented, in writing, to the Speaker of the House of Representatives and the President of the Senate, and to the Committee on Science and Technology of the House of Representatives and the Committee on Commerce, Science and Transportation of the Senate, a comprehensive plan for the proposed transfer, and (2) each such committee has transmitted to the Secretary written notice (within 30 days after receipt of the plan) to the effect that such committee has no objection to the proposed action.

PURPOSE OF THE BILL

TITLE I

The purpose of title I is to authorize appropriations to the National Aeronautics and Space Administration for fiscal year 1982 as follows:

Programs	Authorization fiscal year 1983	Page No.
Research and development	$5,378,400,000	21
Construction of facilities	100,000,000	177
Research and program management	1,168,900,000	199
Total	$6,647,300,000	

TITLE II

The purpose of title II is to authorize appropriation of $14,955,000 for the National Oceanic and Atmospheric Administration to operate a land remote sensing system.

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COMMITTEE ACTIONS

TITLE I

RESEARCH AND DEVELOPMENT

SPACE SHUTTLE

NASA requested $1,718,000,000 for the Space Shuttle program in fiscal year 1983. The funds will support the Space Shuttle production activities, changes/system upgrading activities, and performance augmentation activities leading to a space transportation system with a four orbiter fleet. The Committee deleted $6,500,000 in production activities related to the Space Shuttle/Solar Maximum Mission Spacecraft Retrieval and Repair demonstration and reduced Performance Augmentation activities by $5,000,000 resulting in a total recommended authorization of $1,706,500,000.

Production and Changes/Systems Upgrading. NASA requested $1,585,500,000 for the Space Shuttle Production program in fiscal year 1983. Within this program, the Committee deleted $6,500,000 related to the Space Shuttle/Solar Maximum Mission Spacecraft Retrieval and Repair demonstration resulting in an authorization of $1,579,000,000, for Space Shuttle Production activities in fiscal year 1983.

Last year the Committee requested that NASA and the Air Force review the requirements for additional orbiter vehicles and further requested that the results of this review be submitted to the Congress in December 1981. The Committee is concerned that this review did not get underway in a timely manner to provide an input into the fiscal year 1983 budget process. The Committee continues to believe that additional orbiters will be required to accomplish critical civil and defense missions, to provide flexibility for exploitation of the orbiter capabilities, to provide a backup for an unforeseen loss of an orbiter vehicle, and to eliminate the need for use of expendable launch vehicles.

Within the production and changes/system upgrading line items, the Committee directs NASA to provide appropriate funding for long-lead materials to maintain an option for procurement of additional orbiters. The Committee further requests that the joint NASA/Air Force review of requirements for additional orbiters be submitted to the Congress by August 1, 1982.

Performance Augmentation. NASA requested $60,000,000 for Performance Augmentation activities to meet a Department of Defense launch requirement in October 1985. The Committee recommends a reduction of $5,000,000 and believes that procurement activities can be phased in a manner to avoid any cost and schedule impact. Therefore, the recommended authorization for Performance Augmentation activities in fiscal year 1983 is $55,000,000.

SPACE FLIGHT OPERATIONS

NASA requested $1,707,000,000 for Space Flight Operations programs in fiscal year 1983 including funds for space transportation systems operations capability development activities; development, test and mission support/engineering and technical base activities; advanced programs activities; Spacelab activities; and space transportation sytem operations activities. Within this line item the Committee recommended an increase of $5,000,000 to space transportation systems operations capability development activities; a reduction of $5,000,000 in development, test and mission support/engineering and technical base activities; and a reduction of $8,000,000 in Space Transportation System Operations activities related to the Space Shuttle/Solar Maximum Mission Spacecraft Retrieval and Repair Demonstration. Therefore, that total recommended authorization for Space Flight Operations activities is $1,699,000,000 in fiscal year 1983.

Space transportation systems operations capability development. NASA requested $85,400,000 for space transportation systems operations capability development activities in fiscal year 1983. This funding request reflects the Administration's decision not to proceed with the sole source acquisition of a modified Centaur for launching Galileo and the International Solar Polar Mission but to launch Galileo and the International Solar Polar Mission with an Intertial Upper Stage. Currently, NASA and the Air Force are proceeding with joint studies related to development of a high energy upper stage. The Committee agrees that there is a requirement for a high energy upper stage but believes that NASA should serve as the procuring agency for the development of a high energy upper stage and that the design should accommodate future modification for reusability. Therefore, the Committee recommends and addition of $5,000,000 to complete Phase B definition studies leading to the competitive procurement of an orbital transfer vehicle beginning in fiscal year 1984. The total recommended authorization for Space Transporation Systems Operations Capability Development activities is $90,400,000 in fiscal year 1983.

Development, Test and Mission Support/Engineering and Technical Base. NASA requested $82,400,000 for Development, Test and Mission/Engineering and Technical Base activities in fiscal year 1983. The Committee recommends a reduction of $5,000,000 resulting in a total authorization of $77,400,000.

Space Transportation Systems Operations. NASA requested $1,414,100,000 for Space Transportation Systems Operations activities in fiscal year 1983. The Committee deleted $8,000,000 related to the Space Shuttle/Solar Maximum Mission Spacecraft Retrieval and Repair demonstration resulting in a total recommended authorization of $1,406,100,000.

PHYSICS AND ASTRONOMY

NASA requested $471,700,000 for Physics and Astronomy programs in fiscal year 1983. Within this line item the Committee reduced Mission Operations and Data Analysis activities by $8,200,000 resulting in a total authorization of $463,500,000 for Physics and Astronomy programs in fiscal year 1983.

Mission Operations and Data Analysis

NASA requested $85,600,000 for Mission Operations and Data Analysis activities in fiscal year 1983. The Committee deleted $9,200,000 related to the Space Shuttle/Solar Maximum Mission Retrieval and Repair Demonstration and increased funding available for analysis of data from the High Energy Astronomy Observatory and the Orbiting Astronomical Observatory by $1,000,000. Therefore, the total recommended authorization for Mission Operations and Data Analysis activities in fiscal year 1983 is $77,400,000.

PLANETARY EXPLORATION

NASA requested $154,600,000 for Planetary Exploration programs in fiscal year 1983. Within this line item the Committee increased funding for Mission Operations and Data Analysis activities by $12,000,000 and funding for Research and Analysis activities by $11,000,000 resulting in a total authorization of $177,600,000 for Planetary Exploration programs in fiscal year 1983. The fiscal year 1983 budget would reduce the support for planetary research in universities by approximately fifty percent.

Mission Operations and Data Analysis. NASA requested $26,500,000 for Mission Operations and Data Analysis activities, a reduction of $11,800,000 below the level of the fiscal year 1982 operating plan and a reduction of $23,300,000 below the March 1981 fiscal year 1982 budget request. The fiscal year 1983 budget request would result in the termination of the Pioneer Venus spacecraft, the Pioneer 6-9 spacecraft, Pioneer 10 and 11, as well as Viking mission operations. The Committee recommended an addition of $12,000,000 to Mission Operations and Data Analysis activities resulting in a total authorization of $38,500,000 in fiscal year 1983.

Research and Analysis. NASA requested $35,500,000 for Research and Analysis activities, a reduction of $11,200,000 below the level of the fiscal year 1982 operating plan and a reduction of $16,000,000 below the level of the March 1981 fiscal year 1982 budget request. The fiscal year 1983 budget request would result in termination of the Lunar Curatorial Facility activities, termination of the Infrared Telescope Facility activities, and a significant reduction in support to planetary research in the university community.

The Committee is particularly concerned about NASA's plans to cease support for the Infrared Telescope Facility (IRTF) only three years after completion of the facility which originally cost more than $10 million. Although, NASA expressed a hope that the National Science Foundation would pick up support for the IRTF, no funds were included in the National Science Foundation budget for this purpose nor has such an approach been effectively coordinated with the Foundation. A research facility such as the Infrared Telescope Facility cannot operate efficiently when funding crises occur every fiscal year. Therefore, the Committee directs NASA to continue support for the Infrared Telescope Facility until an interagency agreement between NASA and NSF is completed which provides for NSF support of the facility, or until an independent, outside, scientific peer review finds that the facility should be closed.

The technological strength of our nation depends in great part on the health and vigor of research activities carried out in our universities. The planetary research and data analysis programs within our universities are dependent solely on federal funds and are a resource necessary to maintain world leadership in this area. A declining budget has put severe strains on the health of our planetary exploration program and particularly on the academic space science community. In order to prevent deeper erosion of this valuable technological resource, the research and data analysis authorization for NASA's planetary exploration program was increased by $11,000,000 (including funding for the Infrared Telescope Facility). It is essential that such a minimum research base and the necessary related facilities survive within our universities while a solid planetary exploration strategy is being defined. Therefore, the total recommended authorization for Research and Analysis activities is $46,500,000 in fiscal year 1983.

SPACE APPLICATIONS

NASA requested $316,300,000 for Space Applications programs in fiscal year 1983. Within this line item the Committee recommended an increase of $4,000,000 to continue Technology Transfer activities, an increase of $5,000,000 in Materials Processing in Space activities, and an increase of $5,000,000 in Communications and Information Systems activities. Therefore, the total recommended authorization for Space Applications program in fiscal year 1983 is $330,300,000.

Technology Transfer. In the amended fiscal year 1982 budget request NASA proposed to eliminate technology transfer activities. However, the Congress authorized and appropriated fiscal year 1982 funds for these activities and $5,000,000 was included in the NASA fiscal year 1982 operating plan. NASA has again proposed to eliminate these activities in the fiscal year 1983 budget. The efforts funded in this area are primarily to transfer land remote sensing technology to state and local governments. The Committee notes that the importance of providing a mechanism for transferring remote sensing technology for operational use by public and private organizations requires the applications of NASA expertise and physical resources. Continuing this activity in fiscal year 1983 is particularly important to assure maximum utilization of data from the Thematic Mapper instrument planned for launch on LANDSAT D in September 1982. In order to ensure that the capabilities of remote sensing obtained at great cost are made available for the ecomonic and social benefit of the Nation, the Committee believes it is necessary to continue these activities and recommends an authorization of $4,000,000 for technology transfer activities in fiscal year 1983.

Materials Processing in Space. NASA requested $23,600,000 for Materials Processing in Space activities in fiscal year 1983. In recognition of the potential benefits of materials processing in space and the efforts by other countries in the area, the Committee recommended an increase of $5,000,000 to augment the national effort in exploiting this technology by expanding the materials science and engineering base in the university community. Therefore, the total recommended authorization for Materials Processing in Space activities is $28,600,000 in fiscal year 1983.

Communication and Information Systems. NASA requested $19,900,000 for Communication and Information Systems activities in fiscal year 1983. The Office of Management and Budget reduced the NASA request of $73.4 million for these efforts by $53.4 million in large part due to the deletion of a 30/20 gigahertz test and evaluation flight mission. This deletion was made in part based on the fact that the Department of Defense is proceeding with the Milstar program which would demonstrate 44/20 gigahertz technology. In considering this issue the Committee heard conflicting testimony with regard to the degree to which the Milstar program could satisfy civil requirements. A representative of the Space Applications Board maintained that: "In summary, the military R&D program cannot be expected to demonstrate any systems capability of value to the civil commercial sector. It can be expected to demonstrate some component technology that should be of important value, but probably restricted to the area of microwave transmitters and receivers—not elements such as antennas or switches. And, of course, the military program can be expected to benefit from some NASA supported technology developments in these areas." The Committee has heard convincing testimony with regard to the importance of making the 30/20 gigahertz portion of the frequency spectrum available to the Nation. The Committee continues to believe that advanced communications research and development is an important part of the agency's responsibiity to the civilian sector. Therefore, the Committee recommends an increase of $5,000,000 for technology development and for further study and resolution of the issues associated with any duplication associated with a NASA 30/20 gigahertz test and evaluation flight mission and the DOD Milstar program. The Committee further directs that NASA submit a rescoped 30/20 gigahertz test and evaluation flight mission which would take advantage of appropriate technology from the Milstar program but which would also satisfy the civil commerical sector. Therefore, the total recommended authorization for Communication and Information Systems activities is $24,900,000 in fiscal year 1983.

TECHNOLOGY UTILIZATION

The NASA fiscal year 1983 budget request included $4,000,000 for Technology Utilization activities. The amended fiscal year 1982 budget request for this area was $4,600,000 but through additions in the fiscal year 1982 NASA authorization and appropriations legislation, the funding level was increased to $8,000,000 in the NASA fiscal year 1982 operating plan. The Committee is concerned that the 1983 budget request ignores Congressional direction and intent. The Committee continues to recognize the Technology Utilization program as a model federal program dedicated to the transfer of NASA technology and know-how for social and economic benefits. NASA has reported results of studies which indicate that demonstrated economic benefits are six times the cost of the Technology Utilization program. In addition, the National Aeronautics and Space Aministration Act of 1958, as amended, declares that NASA shall assist in bioengineering research, development and demonstration programs. The Stevenson-Wydler Technology Innovation Act of 1980 in further recognition of the importance of programs exemplified by NASA Technology Utilization, mandated such activities be established across federal agencies. The Committee fully supports the NASA Technology Utilization program and encourages NASA to establish State Technology Application Centers in other states where the potential for industrial innovation through this type of technology utilization program can be demonstrated and where there is a state commitment to support such a program both financially and through complementary state government and private sector initiatives.

In order to assure the continued development and implementation of a technology utilization function that actively applies the full range of the Agency's institutional expertise to non-aerospace technology problems of the industrial and public sectors, the Committee recommends an increase of $5,000,000 for a total authorization of $9,000,000. The Committee directs NASA to maintain a technology applications engineering program that permits field center personnel, associated contractors and the required institutional facilities to be used in applying aerospace technology to such problems. The Agency should as appropriate, develop cooperative arrangements with prospective users of this technology for purposes of defining priority technology utilization objectives, identifying cofunding requirements and assuring expeditious implementation of the transferred technology by the users.

AERONAUTICAL RESEARCH AND TECHNOLOGY

NASA requested $232,000,000 for Aeronautical Research and Technology. This amount represents an 18.6 percent reduction from the amount authorized in fiscal year 1982.

Funding for the aeronautics program has been on a downward path in recent years. For example, actual spending in fiscal year 1980 was $308 million. Exacerbating this trend, the Administration took unilateral action this year to fundamentally change NASA's role in aeronautics as a way of achieving further large reductions in this Federal effort. The vehicle for achieving this action was a revised fiscal year 1982 operaing plan, about which the Committee was not consulted. The change implemented therein was a withdrawal from all technology validation activities, except where a clear military application existed. The underlying assumption is that industry will pick up the slack.

The Committee has been presented with no evidence to indicate that this will be the case. Moreover, the facts show that past investments in research and technology have led to very large commercial benefits for the United States. The Committee sees no justification for tinkering with such a time-proven and cost-effective system.

Therefore, the Committee directs the following restorations: Energy Efficient Transport ($1.1 million); Composite Primary Aircraft Structures ($2.0 million); Advanced Turboprops ($9.8 million); Energy Efficient Engine ($7.0 million); Terminal Configured Vehicle ($5.0 million); Turbine Engine Hot Section Technology ($4.7 million); Advanced Rotocraft Technology and Helicopter Transmission Research ($4.5 million); Broad Property Fuels Technology ($4.2 million); Powered Lift and Tilt Rotor Technology ($3.8 million); and, Research and Technology Base ($6.0 million). To partially offset these additions and to encourage the Department of Defense to reimburse NASA for work that is conducted in its behalf, the Committee directs the following general reduction to be taken from activities that are primarily directed at military application: Low Speed Systems Technology and High Speed Systems Technology ($13.0 million). The new total is $267,100,000.

SPACE RESEARCH AND TECHNOLOGY

The NASA budget request included $123,000,000 for space research and technology in fiscal year 1983. If in the future our Nation is to be in a position to embark on aggressive space initiatives, NASA must strengthen the space propulsion research and technology base. The Committee recommends a total authorization of $128,000,000 for space research and technology base activities including $5,000,000 to augment propulsion research and technology activities.

TRACKING AND DATA ACQUISITION

NASA requested $508,900,000 for Tracking and Data Acquisition programs in fiscal year 1983. Of that amount, $61,300,000 represents funding for the Tracking and Data Relay Satellite System (TDRSS). TDRSS funding for fiscal year is to initiate the repayment of the construction loan, to make operations and award fee payments to the Space Communications Company, and to provide support to the NASA TDRSS project management staff for systems engineering and operations planning activities. The Office of Management and Budget reduced the fiscal year 1983 TDRSS funding by $77,800,000 through an adjustment in TDRSS payment schedules. The Committee believes that additional reductions of $10,000,000 can be made through further adustments in the TDRSS payment schedule and management support efforts. Therefore, the Committee recommends a total authorization of $498,900,000 for Tracking and Data Acquisition activities in fiscal year 1983.

RESEARCH AND PROGRAM MANAGEMENT

NASA requested $1,178,900,000 for Research and Program Management activities in fiscal year 1983. With only one new start in the past four budget years the Committee believes that the agency's institutional funding can be reduced by $10,000,000 without significant impact. The Committee, therefore, recommends a total authorization of $1,168,900,000 for Research and Program Management activities in fiscal year 1983.

LANGUAGE AMENDMENT

FISCAL YEAR 1983 NOAA LANDSAT AUTHORIZATION

Title II provides authority for the Secretary of Commerce to operate a civil land remote sensing system. The Subcommittee adopted an amendment to Title II which would prohibit the use of funds authorized in Title II to transfer land remote sensing ownership or management to the private sector without approval of the authorizing Committees of the House and the Senate.

COMMITTEE VIEWS

U.S. CIVILIAN SPACE POLICY

Our country's space policy is outlined in the National Aeronautics and Space Act of 1958. It is significant that the Nation's leaders made a major provision of that Act the establishment of a civilian agency, separate from the military, to conduct the aeronautical and space activities of the United States government. In addition, the Act provided that the government's aeronautics and space program be balanced across disciplines of space flight, space science, space applications and aeronautics.

In the mid-1970's when the Administration proposed that all production orbiters would be funded in the NASA budget, it was understood that funds for the Air Force orbiters would be provided to NASA over and above NASA ongoing programs. However, NASA has had to absorb these costs, which has increased the budget constraints on other program areas. The resulting reductions and deferrals of high-priority space science, applications and aeronautics programs reflect a lack of understanding on the need for balance.

Press reports of NASA internal memoranda outlining a future agency dirction of increasing emphasis on military technology raise additional concerns. As pointed out above, the National Aeronautics and Space Act of 1958 provides for Independent civil and defense programs which would, however, share information and technology; share launch vehicles; and, where appropriate, operate cooperative programs. Any deemphasizing of efforts on civil space applications and the increased emphasis on military space applications technology as outlined in the internal memorandum is clearly in conflict with the 1958 Act and contradicts Congressional intent, direction, and commitment expressed over two decades.

In order to maintain an appropriate balance in the civil program there is the need for vision, leadership, and continuity of commitment. The recent successes of Voyager and the Space Shuttle have reaffirmed America's present leadership in space technology, but it is questionable whether any vision for the future or continuity of commitment remains.

Then there remains that intangible element called vision. Vision in this case may be defined as long-range planning or goal setting that allows numerous space program possibilities and opportunities to be *balanced* against each other and against other existing national needs. Out of this balancing a program direction could be chosen which would be in the best interest of the Nation. The United States does not have a long-range vision of where we are going in civil space activities. The absence of the vision of a desired future makes it difficult to identify criteria for program decisions.

The failure to set long-range goals and to do long-range planning results in short-term policies which change too often to allow for a cohesive, rational view of our future direction.

NASA's contribution not only to national defense but also to our national economy must be recognized. Only through a strong economy and successful competition in the international civil marketplace can we sustain our national prestige, provide for economic growth, and maintain a strong defense program. Therefore, the Nation must continue to make the incremental investment necessary to strengthen and increase commercial aerospace sales through exploitation of civil space and aeronautical technology having both civil and military applications. The existence of the open space and aeronautics program conducted by NASA contributes significantly to this end.

SPACE SHUTTLE PROGRAM

The Committee congratulates the NASA and industry team for the great success of the first three Space Shuttle flights which have once again demonstrated to the world unexcelled technological genius and greatness. However, major challenges lie ahead before the promise of a flexible, efficient, operational space transportation system can be fulfilled.

Orbiter Fleet Size

The Committee continues to believe that additional orbiters beyond the currently planned four will be needed to accomplish critical civil and defense missions, to provide flexibility for exploitation of the Space Shuttle's capabilities, and to provide a backup to an already committed fleet. Auxiliary systems are also needed to provide increased on-orbit power and mission life. The Committee strongly believes that the Administration should request funds for additional orbiters with plans for shared funding by the Department of Defense and NASA.

Pricing Policy

Since the Space Shuttle pricing policy was first established in 1977, the cost per flight to launch and operate the Space Shuttle has significantly exceeded the original estimates. At the time Congressional approval was given to the pricing policy, NASA projected paying 82 percent of the costs, while flying 55 percent of the flights. More recent estimates indicate that NASA will pay 80 percent of the costs, while flying only 36 percent of the flights. The 1977 pricing policy also gave the Department of Defense a "special customer" status which set a fixed price for defense flights during the initial 6 years of Shuttle operations. The Committee is very concerned that under the 1977 NASA/DOD pricing agreement, shuttle launch costs for Department of Defense missions greatly exceed Department of Defense reimbursements. Therefore, the Committee directs NASA to renegotiate the NASA/DOD pricing agreement to reflect full reimbursement of costs for DOD flights beginning in 1985.

Shuttle Operations

The major goals for the operational success of the Space Shuttle are establishing an adequate orbiter fleet, increasing the number of flights, decreasing turn-around time, and decreasing the cost per flight. NASA faces a major challenge in shifting the organizational and institutional bias from a research and development character to an operational character. NASA's success in meeting this challenge will depend largely on achieving self discipline within the agency in avoiding unnecessary engineering changes, in reducing duplication between government and contractor responsibilities and capabilities, and in evolving an acquisition strategy which makes maximum use of competitive procurements.

UNIVERSITY BASED SPACE SCIENCE

The Committee recognizes that universities, research institutes and NASA centers have all made vital contributions to space science and exploration, and together with the Aerospace industry have brought the United States to its current leadership position in space.

The Committee reaffirms the special importance of unviversity participation in space science research as essential to the "preservation of the role of the United States as a leader in aeronautic space science and technology." (Sec. 102 (c)(5) of the NASA Act of 1958) since only through strong university programs can the preparation of the next generation of space scientists and engineers be assured.

Therefore, the Committee encourages NASA to include in its program planning specific steps designed to ensure the future vitality and productivity of university-based research and training in the space sciences. Such proposals should clearly reflect the importance of balanced programs in Planetary Exploration, Physics & Astronomy, and the Life Sciences to the continued health of basic space science and education.

PLANETARY EXPLORATION

The planetary exploration program has been the source of much national pride and international prestige. The program objectives are to understand the origin and evolution of the solar system, to better understand the Earth through comparative studies with the other planets, and to understand how the appearance of life in the solar system is related to the chemical history of the system. The preeminence of the United States program of planetary exploration has been based on technology leadership and on a foundation of strong, coordinated research and analysis programs.

The Committee is deeply concerned with the deemphasis of NASA's planetary activities just at the time other nations are planning increased planetary efforts. The Soviets have successfully landed spacecraft on, and drilled into the surface of Venus. The Soviets, Europeans, and Japanese are planning to launch spacecraft to study Halley's comet, while the United States has no plans. While the Soviets and others gain knowledge and improve their systems and sensors for the future, NASA is preparing to retire from the competition.

The fiscal year 1983 budget request reflects the beginning of the end for planetary exploration with the deletion of the Venus Orbiting Imaging Radar mission, termination of operations of the Pioneer spacecraft, and reduction of support to the university community by fifty percent.

In April 1981, the Subcommittee on Space Science and Applications recommended that NASA should reaffirm the Nation's commitment for continued exploration of our solar system through intensive investigation of other planets. The Space Science board recently released a report, "Strategy for Earth Science from Space in the 1980's" which concluded—"A continuing challenge to the earth and planetary sciences is to account for the profoundly unique attributes of the Earth in the context of the common processes that have shaped the formation and evolution of the solar system."

The Committee on Science and Technology disagrees with the view expressed by critics that planetary exploration activities should be relegated to a position of secondary importance but supports the following view put forth in the 1978 Space Science Board Report, "Strategy for Exploration of the Inner Planets:"

> Scientific interest in the planets lies in the expectation that investigation of these bodies will contribute greatly not only toward unraveling the evolution of the solar system but also that it will enhance our understanding of the processes that take place in the atmosphere, the oceans, and the deep interior of the earth. * * * By acquiring an understanding of the solar system and its components, our ability to decipher the evolutionary course of the earth and its environments will be significantly enlarged.

The Committee firmly believes that a renewed commitment to the planetary exploration program will expand the frontiers of technology as well as the scope of human inquiry and imagination. These are the basic ingredients necessary for sustaining a productive, inventive Nation.

SOLAR ELECTRIC PROPULSION

After the completion of Galileo and VOIR, a major gap in our basic comprehension of the solar system will be the knowledge of the primative bodies—comets and asteroids. They thus take on special priority for near-term reconnaissance missions. The multitude and diversity of the primative bodies and their orbital characteristics argue strongly that the most efficient mode of exploration utilizes low-thrust propulsion. Low-thrust propulsion also provides a beneficial flexibility in the conduct of other outer planetary missions and in launch-date flexibility. Therefore, the Committee urges that the basic low-thrust technology be maintained in a state of readiness for initiation of development.

SPACE APPLICATIONS

The Committee continues to express strong support for a vigorous program of civilian space applications as the key element of assuring maximum utilization of space technology for the benefit of mankind. Although the United States has served as the leader in development of satellite communications technology and remote sensing technology, this leadership is being challenged by the Europeans and Japanese.

The successful exploitation of space technology for practical earth benefit involves not only the development of the technology but the transfer of technology and development of an infrastructure involving institutions and people outside the aerospace community who are unfamiliar with space applications capabilities. Institutional issues involving the respective roles of NASA and other Federal agencies and the role of government vis a vis the private sector are the major inhibition to broader application of space capability. Therefore, NASA must present itself as a steady and reliable partner in developing and demonstrating space technology for earth applications.

The Committee believes that we have only scratched the surface in the application of remote sensing to the oceans, to the weather, and to the land. While weather satellites have been in use for 22 years, we continue to improve our use of the information they provide. LANDSAT D, when launched later this year, will begin to provide information from totally new spectral regions. If the appropriate research investment is made, we can anticipate great benefits from this information. The short-lived SEASAT gave us a hint of what can be learned from sensing the oceans in new spectral regions. The Committee emphasizes that we need more research on the meaning of the remotely-sensed data and more interaction with the user communities in order to discover and develop the most productive applications. Further, a better understanding in both these areas will enable NASA to better plan their future research programs.

Another area the Committee believes to have great potential is materials processing in space. This potential probably will take two different routes: Certain very high-value, low-volume materials—such as phamaceuticals—may actually be produced, purified, or otherwise processed in space where zero-gravity makes possible some things that cannot be done on earth. Other materials or processes will be studied in space in order to improve the understanding of processes to be carried out on earth. This improved understanding can then be used to improve yield, performance or cost of the terrestrial processing. Again there is a need for technology transfer activities to develop understanding and an infrastructure to take advantage of the technology associated with materials processing in space. The Committee strongly encourages NASA to conduct the vigorous applications program needed to develop such an infrastructure.

PROGRAM MANAGEMENT

The Committee requests that NASA submit on a semiannual basis project status reports on major programs including the Space Shuttle, Galileo, Space Telescope, Landsat D, International Solar Polar Mission, and the Gamma Ray Observatory. These reports should contain descriptive information about the programs including progress, problems and pending decisions. Any variance in the program milestones, cost, scope or performance should be analyzed.

In addition, the Committee requests that NASA report to it within 30 days of determining that an overrun of 15 percent or more will occur on any major project, including the Space Shuttle and associated projects such as the Filament Wound Case for the Solid Rocket Boosters, Space Telescope, Galileo, Landsat D, Gamma Ray Observatory, and any development of a new upper stage for the Shuttle.

The Committee also requests that NASA provide a detailed assessment on each new program start of how the recommendations of the Hearth study are being implemented for that program. The Committee further requests such an assessment for the Gamma Ray Observatory be submitted by September 30, 1982.

DOE SPONSORED ENERGY R&D

The Committee is concerned that NASA's reported plan to phase down and eliminate its management of Department of Energy R&D programs during fiscal year 1982 and 1983 will foreclose Congressional options on the fiscal year 1983 DOE budget. Therefore, the Committee directs NASA to protect the capability at the Lewis Research Center and the Jet Propulsion Laboratory to continue managing the large wind, vehicle propulsion, electric and hybrid vehicle, photovoltaic, solar and fossil R&D programs until final Congressional decisions are reached. The Committee believes that an energy staff of at least 160 civil service personnel at Lewis is required to maintain the current high quality operation of these important national programs.

EXPLANATION OF THE BILL

TITLE I

The bill authorizes Research and Development in section 101(a), Construction of Facilities in section 101(b), and Research and Program Management in section 101(c). These activities are explained below.

RESEARCH AND DEVELOPMENT

SUMMARY

	Authorization, FY 1983	Page No.
1. Space Shuttle	$1,706,500,000	
2. Space flight operations	1,699,000,000	
3. Expendable launch vehicles	42,800,000	
4. Physics and astronomy	463,500,000	
5. Planetary exploration	177,600,000	
6. Life sciences	55,700,000	
7. Space applications	330,300,000	
8. Technology utilization	9,000,000	
9. Aeronautical research and technology	267,100,000	
10. Space research and technology	128,000,000	
11. Tracking and Data Acquisition	498,900,000	
Total	5,378,400,000	

1. SPACE SHUTTLE, $1,706,500,000

FISCAL YEAR 1983 FUNDING LEVEL

Production	$1,579,000,000
Changes/systems upgrading	72,500,000
Performance augmentation	55,000,000
Total, Space Shuttle	1,706,500,000

The Space Shuttle is the key element of a versatile, economical space transportation system that will provide a wide variety of national and international users with round trip access to space beginning in the 1980's. The Space Shuttle is the first reusable space vehicle, and is configured to carry many different types of payloads to and from low Earth orbit. Its development will provide multipurpose, economical space operations for Earth applications, scientific, defense, and technological payloads. The Space Shuttle is, however, much more than just a transportation vehicle. It will offer unique capabilities that cannot be achieved with today's expendable launch vehicles—to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; to transport materials and equipments to orbit; and to perform rescue missions. These capabilities will greatly enhance flexibility and productivity, and result in savings in the cost of space operations.

The Space Shuttle consists of four basic flight hardware elements—the orbiter, the main engines, and expendable external propellant tank (ET), and twin solid rocket boosters (SRB)—plus launch and landing systems. The orbiter is the reusable spacecraft portion of the Space Shuttle. Its large payload volume of 285 cubic meters (370 cubic yards) and cargo carrying capacity of up to 29,500 kilograms (65,000 pounds) will permit payloads to be built to less restrictive design requirements. The orbiter vehicle will carry personnel and payloads into orbit to perform their assigned tasks and return them to Earth. The orbiter is roughly the size of a DC-9 aircraft and contains three liquid fueled reusable main engines. It also provides a habitable environment for a crew which will include scientists and engineers.

The Space Shuttle is launched into space by the thrust of its three liquid/hydrogen main engines, burning in parallel with the twin solid rocket boosters. Two minutes into the flight, at an altitude of about 45 kilometers (24 nautical miles), the solid rocket boosters burn out, separate, and descend by parachute to a soft splashdown in the ocean about 260 km (140 nautical miles) downrange. They then are recovered for refurbishment and reuse. The three main engines continue to burn for another six and one-half minutes. Just before orbital insertion, the engines are shut down and the external tank jettisoned. Following a ballistic trajectory, the empty tank reenters, tumbles, and breaks up over a remote ocean area about 18,500 kilometers (10,000 nautical miles) downrange. The orbiter, aided by its orbital maneuvering engines, enters Earth orbit to perform its mission. After competing the mission, the orbiter again fires its orbital maneuvering engines to deorbit and reenter the atmosphere for its approach and landing.

The Space Shuttle will usually have a crew of three: the commander, the pilot, and the mission specialist. On some missions, up to four more mission or payload specialists may be added. The crew will experience forces not greater than three times that of gravity during launch and landing, and is able to perform their work in a shirt-sleeve environment.

Prelaunch preparations are underway for the third (STS-3) of the four Space Shuttle flights in the development orbital flight test program. The STS-3 launch is scheduled for mid-March 1982, and is scheduled to land at the Dryden Flight Research Facility—Edwards Air Force Base.

Main engine activities have consisted principally of single engine testing culminating in the completion in FY 1981 of the preliminary flight certification program which qualified the engines for the first orbital flight. The engines performed flawlessly during the first flight of the Columbia, requiring only inspections and minor maintenance to prepare them for the second flight. Testing was inititated on the full power level (FPL) version of the main engine during FY 1981. The technical problems which were discovered in this early development testing (two main injector liquid oxygen post failures, a fuel preburner liquid oxygen post failure, and a fuel turbopump turbine failure) have been corrected. Testing is continuing in support of the FPL certification program which was initiated early in FY 1982.

The two remaining external tanks of the heavyweight configuration, along with the first six lightweight tanks, are in various states of manufacture at the Michoud Assembly Facility.

In 1981, SRB subsystem component qualification tests were completed to support the STS-1 flight and to qualify components for reuse capability. The flight hardware was assembled for the second orbital flight test. Repair of the aft skirts damaged during water impact on STS-1 was started and should be completed early in 1982.

At the Kennedy Space Center, the first line of Space Shuttle processing facilities and ground support equipment are fully activitated and have successfully supported the vehicle assembly, tests, servicing, checkout and launches for STS-1, STS-2, and STS-3. The processing activities also included the replacement of defective vehicle parts, changeout of payloads, orbiter deservicing and ferrying from the Dryden Flight Research Facility landing site to the Kennedy Space Center, and retrieval of SRB's from the Atlantic Ocean and subsequent disassembly. The processing procedures, software, and launch processing system are functioning well and the work force is supporting critical path processing on a schedule of three shifts a day, six days per week.

The second, third, and fourth flight orbiters are in various stages of manufacturing. Challenger, Orbiter 099, is scheduled for delivery in mid-1982. Substantial parts of its airframe were used during the development phase to test the structural dynamics of the vehicle under various load conditions; the modifications to convert it into a flight orbiter are nearly complete. Discovery, Orbiter 103, is well into the structural assembly phase at the Rockwell facility in Downey, California, and at the various subcontractor facilities around the country; OV-103 is planned for delivery in September 1983. Atlantis, Orbiter 104, is in the early stages of primary structure buildup; its delivery is scheduled to occur in December 1984. However, within the available funding for FY 1982, the highest priority has been assigned to maintaining the delivery schedule for Orbiter-099 and Orbiter-103; certain Orbiter-104 activities scheduled for FY 1982 may have to be rephased. Procurement of the necessary supporting hardware, such as the remote manipulator system and television cameras, is underway on a schedule which supports the above orbiter delivery dates.

The production main engines required to support the testing and flight program are currently being delivered. These engines are in the full power level configuration, providing thrust levels at 109% of the rated power level engines used for the first flights of Orbiter Vehicle-102, Columbia. Seven productions engines are scheduled for delivery in FY 1982.

At the Kennedy Space Center, a number of the second line of processing facilities are nearing completion. Activation of the second bay of the Orbiter Processing Facility, the second SRB and ET checkout bay and second vehicle assembly bay in the Vehicle Assembly Building, and the second mobile launcher platform has been accelerated to receive and process Challenger independently of Columbia when Challenger is delivered in mid-1982. The readiness date for the software development facility in the launch control center firing room, is also being accelerated to support this independent second line. Work on the second firing room, second launch pad, and increased rate capability in other work stations is underway, with activation planned for subsequent years.

Spares and equipment funds provide for the initial operational inventory of crew equipment, necessary spares for flight hardware and ground support equipment, plus ET and SRB production rate tooling. This includes orbiter flight spares, orbiter and launch site ground support equipment spares, the extravehicular mobility units (each comprised of a space suit assembly, a primary life support system, and a portable oxygen system), main engine spares, and ET and SRB production tooling to support the operational flight rate buildup.

PRODUCTION

FISCAL YEAR 1983 FUNDING LEVEL

Orbiter	$927,000,000
Main engine	262,000,000
Launch and landing	67,000,000
Spares and equipment	323,000,000
Total, Production	1,579,000,000

Orbiter

The Space Shuttle production program is based on a national fleet of vehicles currently approved as four orbiters. Three orbiter vehicles are now being procured in the production phase: Challenger, Discovery, and Atlantis. Challenger (Orbiter 099), used in the Design, Development, Test, and Evaluation (DDT&E) program as the structural test article, is being modified to an operational vehicle while Discovery (Orbiter 103), and Atlantis (Orbiter 104) are being manufactured as new vehicles. Columbia (Orbiter 102—the DDT&E vehicle) will be modified to an operational configuration after completion of the orbital flight test program. The prime contractor for the production orbiters is Rockwell International, Shuttle Orbiter Division. The planned delivery schedule for the production orbiters is: Orbiter 099—June 1982; Orbiter 103—September 1983; and Orbiter 104—December 1984. However, within the available funding for fiscal year 1982, maintaining the delivery schedule for Orbiter 099 and Orbiter 103 has been assigned the highest priority; certain Orbiter 104 activities scheduled for fiscal year 1982 may have to be rephased if necessary.

With the exception of the forward reaction control system and the orbital maneuvering system pods, all major components for Orbiter 099 have been shipped to the Palmdale final assembly facility. These major components have been assembled and final systems installation is underway. There are over 20,000 thermal protection system tiles installed with approximately 10,000 tile installations remaining. Integrated systems testing was initiated in early November 1981 and is proceeding satisfactorily; delivery of the vehicle by Rockwell to NASA is anticipated to occur in late June 1982.

Orbiter 103's manufacturing is well underway. Early fiscal year 1982 deliveries to Palmdale from the major subcontractors and Rockwell include the mid-fuselage, the wings, the payload bay doors, and the upper and lower forward fuselages. This will be the first time two flight vehicles will be at Palmdale simultaneously. During the remainder of fiscal year 1982, the vertical stabilizer will be shipped, the major components will be assembled, and the thermal protection system and secondary structure installations will begin. The major subcontract effort on Orbiter 104 has been initiated and Rockwell has started assembly of the aft fuselage at the Downey, California facility.

The follow-on remote manipulator system production contract with SPAR Ltd. in Toronto, Canada is on schedule. The first production unit is scheduled for delivery to the Kennedy Space Center in the third quarter of fiscal year 1982. The supporting systems integration, procurement of ancillary hardware (such as the closed circuit television cameras used on the orbiters), upgrading of the Johnson Space Center software production facility, post-OFT test program, and increased flight simulation capability are also included in this program element. The present orbiter program objectives do not include provisions for the modifications to the production orbiters and the related system integration analyses required to support the use of the Centaur as a Shuttle upper stage.

During fiscal year 1983, the Orbiter-103 crew module, aft fuselage, forward reaction control system, and orbital maneuvering system pods will be shipped to Palmdale. Thermal protection system installation will be started on these items and will continue on the components that were delivered in fiscal year 1982. The systems installations will be completed, and the vehicle will undergo integrated acceptance testing and checkout. As part of the weight reduction program, the new lighter weight tile FRCI-12 will be used in place of the LI-2200 tiles on the Orbiter-103 vehicle.

During FY 1983, work will proceed at the major subcontractors on the Orbiter-104 mid-fuselage, wing, and vertical stabilizer. The aft fuselage and the crew module will be in work at the Downey facility.

Orbiter-102, after completing STS-5, currently scheduled for November 1982, will be modified to full operational status based on the latest design and design, development, test and evaluation flight test requirements. This will be a considerable effort at Palmdale and will be accomplished entirely in FY 1983.

The FY 1983 estimate incorporates the initiation and completion of factory checkout of Orbiter-103 at Palmdale, prior to its delivery to KSC, utilizing the automatic checkout equipment; continuation of software development for later flights in FY 1983 which includes the changes resulting from orbital flight tests and other operational mission unique payloads; and the continuation of the acquisition and use of the software production facility in FY 1983. The software production facililty is required to support the operational software activities and mission unique operational flight packages. The acquisition phases of the software production facility are scheduled to be completed in FY 1987. The amount requested also includes provisions for continuing support for preflight prepartation and postflight analysis of: (1) defined flight test requirements deferred or not accomplished during orbital flight test; (2) additional requirements based upon flight results; and (3) vehicle design changes not yet identified. In addition, FY 1983 funds will be used to support continuing development of the Shuttle mission simulator mission-to-mission reconfiguration effort to augment the existing Shuttle mission simulator's capacity and provide additional part-task training capability.

Other activities to be pursued include crew training loads standardization, procurement of additional closed circuit television equipment for Orbiter-103 and Orbiter-104, and continued engineering support in the key disciplines of flight performance, aerodynamics, flight techniques, orbiter development, and flight design. Further, provision has been made for the support of the Solar Maximum retrieval/repair mission and the completion of the second manned maneuvering unit.

MAJOR PROJECT ACTIVITIES PLANNED FOR FY 1983

Modification of Orbiter-102 to an operational vehicle.

Manufacture of Orbiters-103 and -104 resulting in delivery of Orbiter-103 at the end of FY 1983.

Shipment of Orbiter-103 crew module aft fuselage, forward reaction control system, and orbiter maneuvering system pods to Palmdale for thermal protection system installation.

Work will proceed at the major subcontractor level on the midfuselage, wing, and verticle stabilizer of Orbiter-104.

Main Engine

The production budget provides the material procurement, fabrication, and assembly operation necessary to support the orbiter fleet with full power level (FPL) engines. The first production (FPL configuration) engine was assembled in early FY 1982. From materials procurement to final main engine assembly covers a time span of about 42 months. Then another few months are required for shipping to the National Space Technology Laboratories (NSTL), test stand installation, acceptance testing, final checkouts, and inspections before delivery to KSC. In FY 1983, the materials procurement, fabrication, and assembly operations necessary to support the orbiter production and flight schedule will continue.

Residual development activity will also be pursued starting in FY 1983 within the production program. This includes single FPL engine testing, culminating in certification during FY 1983. Subsequent testing will be focused on demonstrating the life capability of the main engine; this effort will demonstrate appropriate maintenance intervals for flight program use, identify components which should be redesigned for longer life, and continue the expansion of the engine certification program to certify the engine for an increased number of missions. Eventually, the main engine is planned to be certified for 55 missions.

FY 1983 funds are required to continue the fabrication and assembly of FPL configuration flight engines. Component deliveries such as a main injector, turbopumps, main combustion chamber parts, etc., will be phased to support the fabrication and assembly operations. Fabrication, assembly and acceptance testing of engines for installation into Orbiter-103 will be completed. The fabrication of components for the completion of engines for the orbiter fleet will be phased throughout FY 1983 to meet the assembly requirements and planned delivery dates in succeeding fiscal years. After assembly, each engine is transported to NSTL for acceptance testing. This effort requires logistics, evaluation, and analysis support. In addition, FPL certification testing will be supported, resulting in certification of the FPL engines in FY 1983 for ten missions. Life/maintenance demonstration testing will be initiated at the completion of the FPL certification testing.

MAJOR PROJECT ACTIVITIES PLANNED FOR FY 1983

Fabrication, assembly, and acceptance testing of engines to outfit Orbiter-103.

Continuation of fabrication and assembly of FPL configuration flight engines.

Phasing of fabrication of components for the completion of engines for orbiters to meet assembly requirements and delivery dates for upcoming fiscal years.

Launch and Landing

The launch and landing project provides for the production and activation of a second line of vehicle processing stations at the Kennedy Space Center (KSC) to support the processing of two or more Space Shuttle vehicles simultaneously. Included in the second line facilities are a second high bay in the Orbiter Processing Facility (OPF), a second set of high bays in the Vehicle Assembly Building (VAB), a second mobile launch platform (MLP), a second launch pad, a third firing room in the launch control center (LCC), and a solid rocket motor (SRM) processing facility. In addition, temporary office housing is required for the non-hands-on launch support personnel overflowing the LCC and VAB as more space in these facilities is being activated for vehicle processing and as safety considerations require people to move out of the VAB. System engineering effort is required to ensure the orderly activation of facilities and implementation of changes to specifications, drawings, and documentation that have occurred during first line activation efforts.

The basic facilities exist for the second line high bays in the OPF and VAB, and for the second MLP, second launch pad and third firing room in the LCC. Ground support equipment is being procured and installed in all of these second line processing stations; the OPF, MLP, and VAB second line facilities will all be activated during FY 1982. The firing room is to be activated in FY 1983 and the launch pad is to be activated at the end of FY 1986. Construction of the solid rocket booster processing facility is scheduled to be initiated in FY 1982 and activation is scheduled in FY 1984. The temporary office housing will consist of railroad boxcars and leased trailers which will be obtained, sited, and activated in FY 1982. All of these second line facilities are on schedule to meet the activation dates stated.

The thrust of the FY 1983 effort will be to design, install, checkout, and validate the second line of facilities and ground support equipment for the DOD-secure third firing room, the solid rocket motor processing station set and Launch Pad B.

Firing room 3 in the Launch Control Center will be modified and activated for DOD-secure missions requiring secure launch operations. This effort will be in process in FY 1982 and completed in FY 1983 to support required launch dates and DOD launch schedules.

Work on the solid rocket motor processing station will be initiated in FY 1982, continue throughout FY 1983, and be completed in FY 1984. This facility will support the receiving, inspecting, rotating, testing, storing, and aft segment buildup prior to stacking in a VAB assembly station.

Although the operational readiness date for Launch Pad B is in FY 1986, intensive effort must begin in FY 1982 and continue through FY 1983 to develop installation plans and initiate long-lead procurements for ground support equipment (GSE). A major effort will be to update the design for Pad B. Design work will be done under the installation contract to lay out the procedures for installing the ground work equipment at the pad. Among the many items of ground support equipment to be procured and fabricated, some major ground support equipment procurements for the pad will be the gaseous oxygen vent arm, the ET vent arm, the orbiter access arm, and initial procurement for the payload ground handling mechanism (PGHM).

MAJOR PROJECT ACTIVITIES PLANNED IN FY 1983

Complete activation of the DOD-secure firing room in the launch control center.

Continue construction and outfitting of the solid rocket motor processing facility to meet the FY 1984 operational readiness dates.

Continue modification and outfitting of Pad B to meet the FY 1986 operational readiness date.

Spares and Equipment

This program element provides for the initial lay-in of spares adequate for replacement of Shuttle components, the tooling requirements for higher external tank and solid rocket booster production rates and the procurement of adequate levels of flight crew equipment.

Initial spares include primarily line replaceable units, or those items for which the optimum maintenance action is removal from the vehicle and replacement. In some cases, economic analysis supports providing initial spares at the shop replaceable unit level as well. The initial spares funding line includes costs of flight spares, ground support equipment spares, and the logistics support analysis to properly estimate and procure these spares. Failure rate for each item and the turnaround time for item repair are two significant factors in determining the quantity of initial spares to be procured. Initial spares are considered to be an investment in the program capability to reach the flight rates and processing times required by the operational mission model.

Tooling modifications required to accommodate the external tank (ET) lightweight configuration continue both at the Michoud Assembly Facility (MAF) and at the subsystem hardware vendor facilities. Also, a number of major weld and thermal protection system tooling procurements required to achieve higher ET build rates are continuing in work. Tooling additions and modifications to accommodate higher build rates are also continuing at the solid rocket booster subcontractor facilities and at the Kennedy Space Center for the solid rocket booster subsystem hardware.

Sufficient initial spares are being procured to provide support for a flight rate of 13 flights in 1985, with the provision to procure at least one of every functional line replaceable units by that time. Test and turnaround support will also be commensurate with that rate. External tank producibility efforts initiated under the design, development, test and evaluation program in prior years will be pursued in the production program; the goal of this activity is to reduce future external tank costs by identifying producibility improvements in assembly and manufacturing operations. Tooling modifications and additional tools to accommodate higher hardware build rates will continue at both external tank and solid rocket booster prime contractor and subcontractor facilities. The production of crew items will result in a space suit inventory of thirteen training and nineteen flight suits at the end of FY 1983, with all five sizings available. This inventory plus the life support system and related spares will support flight and backup crew needs for training through STS-15 and for flights through STS-14.

MAJOR PROJECT ACTIVITIES PLANNED FOR FY 1983

Procurement of adequate initial spares to support flight rate of 13 flights in 1985.

Pursuance of ET producibility efforts in production program to reduce future ET costs.

Accommodation of higher hardware build rates by tooling modifications and procurement of additional tools.

Support of flight and backup crew spacesuit and related equipment needs for flights through STS-14 and training through STS-15.

CHANGES AND SYSTEMS UPGRADING

FISCAL YEAR 1983 FUNDING LEVEL

Changes and systems upgrading	$72,500,000

Management, technical flight experience, and cost reviews of the Space Shuttle program have stressed the need for providing an adequate allowance for changes and modifications which inevitably are required in a large, complex, and technically demanding space system.

The changes and systems upgrading budget represents the estimated requirement for potential changes and systems modifications and unanticipated developments which are not included in the budget estimates for development and production. Such funds are necessary to provide for programmatic and technical changes which result from Space Shuttle development ground and flight testing, and experience in the production phase. Those changes include modification to the orbiters to improve flight performance and system reliability, changes and upgrading of ground systems to reduce turnaround time between missions, and replacement/modification of hardware elements to achieve increased operating economies.

As the changes and upgrading requirements are identified and approved, funds are allocated to the appropriate budget account.

The funding requested for fiscal year 1983 represents the amount required to initiate the modifications under consideration which have been identified to improve reliability, increase operating efficiency, and reduce costs. Changes and upgrading areas of interest include modifications to flight and ground systems; design and development of hardware/software systems which meet requirements for improved safety, reliability, performance and cost-effectiveness; and changes which will reduce operational costs by extending operational life, facilitating improved mission-to-mission turnaround time, and achieving improved mission performance margins. Specific changes and system upgrading enhancement candidates include reaction control system changes to improve reliability and redundancy; a redesigned auxiliary power unit; landing gear improvements; minor modifications to the main engines; tape recorder upgrading for increased storage and reliability; increased orbiter autonomy for onboard checkout and control; and, procedure and hardware changes which would reduce turnaround times, enhance operational capability, and reduce cost-per-flight.

PERFORMANCE AUGMENTATION

FISCAL 1983 FUNDING LEVEL

Performance augmentation	$55,000,000

As Space Shuttle development has progressed, some erosion in payload capability and performance margins occurred, primarily as a result of growth in system inert weight, particularly in the orbiter. Present projections show that even if planned orbiter weight reduction measures and other system improvements are fully successful, some augmentation of ascent performance will be needed to support certain national security missions. This additional capability will be required to support a scheduled launch from the Western Space and Missile Center in October 1985.

Based upon comprehensive assessments of mission requirements and detailed systems engineering and tradeoff studies of several performance augmentation options, NASA has decided to reduce the inert weight of the solid rocket boosters by using filament wound motor case segments to replace the heavier steel cases. This augmentation in performance would be available for missions launched from both the east coast and the west coast launch sites. In addition to satisfying the performance requirements of certain national security missions, the availabililty of the lighter weight filament wound motor case segments for other missions—where performance margins would otherwise require higher performance levels from the main engine and fine tuning of mission plans—is expected to lower the operating and maintenance costs.

In order to meet the October 1985 flight availability date, filament wound case design and overall space transportation system integration activities are being initiated in FY 1982. Fabrication of development segments will start early in FY 1983 to support hydroproof tests and structural tests during the last half of the fiscal year.

Two development motor test firings are planned in FY 1984 and one qualification motor firing in FY 1985 to support the October 1985 need date. Fabrication of flight sets will begin in the fourth quarter of FY 1984.

The filament wound case segments will be obtained through competitive bid from qualified vendors in the industry. Thiokol will continue as integration contractor for the solid rocket motor using the filament wound motor case segments and Rockwell International will be tasked with the overall integration analyses for the Shuttle system.

2. SPACE FLIGHT OPERATIONS, $1,699,000,000

FISCAL YEAR 1983 FUNDING LEVELS

Space transportation systems operations capability development	$90,400,000
Development, test and mission support/Engineering and technical base	77,400,000
Advanced programs	11,900,000
Spacelab	113,200,000
Space transportation system operations	1,406,100,000
Total space flight operations	1,699,000,000

The Space Flight Operations program includes space transportation systems operations capability development; the common support activities conducted under development, test and mission support (engineering and technical base); advanced programs, Spacelab; and space transportation system operations.

Space transportation system (STS) operations capability development provides for space transportation system development activities other than the Space Shuttle. These development and support activities are necessary for the orderly transition to STS operations. Principal areas of activity include the STS upper stages, multimission and payload support equipment, Mission Control Center upgrading (Level II), payload and operations support, and STS operations effectiveness.

Development, test and mission support/engineering and technical base provides the common engineering, scientific, and technical support required at the Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center, and the National Space Technology Laboratories for space transportation systems research and development activities.

The advanced program effort provides technical as well as programmatic data for the definition and evaluation of potential future space missions and systems. In support of this effort, advanced development activities are conducted to provide a basis for obtaining significant performance reliability improvements and reducing future program risks and development costs through the effective use of new technology.

The Spacelab is a major element of the space transportation system. The program is being carried out jointly by NASA and the European Space Agency (ESA). NASA's support of ESA's Spacelab development effort includes development of support equipment not provided by ESA. Other activities include procurement of flight hardware and system activation activities which assure Spacelab compatibility with the orbiter leading to an operational capability.

Space transportation system operations will provide the transportation services and operational activities to bring about a new era in capitalizing on the unique advantages of space to achieve expansion of human knowledge and practical benefits on Earth. The space transportation system operations activities integrate the Space Shuttle system, the Spacelab, and the upper stages into a versatile system; accomplish mission planning; provide the operational recurring hardware and consumables; and support all launch, flight, recovery, crew, and related activities.

SPACE TRANSPORTATION SYSTEMS (STS) OPERATIONS CAPABILITY DEVELOPMENT

FISCAL YEAR 1983 FUNDING LEVEL

Space transportation system upper stages	$37,000,000
Multimission and payload support equipment	16,900,000
Mission control center (MCC) upgrading (Level II)	22,500,000
Payload and operations support	10,000,000
Space transportation system operations effectiveness	4,000,000
Performance augmentation studies	....
Total STS operations capability development	90,400,000

The space transportation systems operations capability development activity includes several major areas of effort. The STS upper stages currently under development consist of the inertial upper stage (IUS) and the spinning solid upper stage (SSUS). They are expendable, propulsive stages required to provide the capability to deploy Shuttle-launched payloads to high energy orbits not attainable by the Shuttle alone.

Multimission and payload support equipment consists of ground and flight hardware used for interfaces between the payloads and the space transportation system, as well as test equipment to verify payload integration compatibility. This class of hardware will be developed into a standard, reusable inventory to support a variety of payloads.

The Mission Control Center (MCC) upgrading (Level II) is the reconfiguration of the Johnson Space Center Mission Control Center to support the STS operational flight schedule requirements. Level II will provide additional hardware, equipment, and software to upgrade the MCC to provide the capability to support three simultaneous orbiter operations.

The payload and operations support activity consists of two major efforts; orbital flight test (OFT) payload integration and the

Payload Operations Control Center (POCC). The orbital flight test payload integration provides for the integration of payloads on the OFT flight. The POCC, to be located at the Johnson Space Center, will provide facilities for command and control of Shuttle/Spacelab attached payloads.

STS operations effectiveness involves developing ways to improve the operational effectiveness and performance of the STS in the following areas: vehicle hardware, vehicle turnaround/cargo processing, system software automation, mission operations, and management procedures.

Performance augmentation will be initiated to improve Shuttle performance capability. Improved performance is necessary for certain missions launched from Vandenberg Air Force Base (VAFB) and to accommodate new payloads and new space utilization concepts.

FY 1983 funding for the multimission and payload support equipment is required for development, testing, and orbiter installation of mixed cargo hardware, and transportation multimission support equipment.

Upgrading the Mission Control Center (Level II) will continue during fiscal year 1983, completing elements of the basic upgrade, including the POCC interface in support of Spacelab.

FY 1983 funds will be used to continue to work toward the completion of the checkout and testing of the POCC in order to meet the readiness data required to support the operational flight schedule requirements. Orbital flight test payload integration funding in FY 1983 is required for OFT post flight activities.

FY 1983 funding will be used to initiate design and development of improvements to the space transportation system to achieve operational effectiveness. Areas currently identified include changes to reduce vehicle turnaround times, simplification of cargo processing, and flight mission operations and improved risk management.

Space Transportation Systems (STS) Upper Stages

The STS upper stages are required to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. These stages are the inertial upper stage (IUS) and the spinning solid upper stages (SSUS).

The IUS is being developed under a Department of Defense contract, to meet upper stage requirements for heavy payloads to be placed in high Earth orbit (up to 5,000 pounds in geosynchronous). Plans for development of a NASA three-stage IUS were cancelled during FY 1981 due to schedule problems, a lack of confidence in performance estimates, and a significant cost increase. Study and definition efforts began in FY 1981 for use of the Centaur as an upper stage in time for the planned Galileo launch in 1985 and the International Solar Polar Mission in 1986. Development of Centaur/STS was not provided in the FY 1983 budget because of the early year funding requirements. NASA is currently planning to modify the two-stage IUS for the Galileo and International Solar Polar Mission.

The IUS payload capability exceeds the capability needed by many geosynchronous payloads using currently available expendable launch vehicles. The SSUS is being developed commercially for these smaller payloads in two weight classes. The Delta class, SSUS-D, will be capable of injecting up to 2,750-pound payloads into geosynchronous transfer orbit. The Atlas-Centaur class, SSUS-A, will be capable of injecting 4,400-pound payloads into the same orbit. Spacecraft apogee motors place the spacecraft (1,400 and 2,250 pounds respectively for SSUS-D and SSUS-A) into final geosynchronous orbit. The SSUS-A and SSUS-D offer launch economies to the user community. These relatively low cost upper stages have simple physical and functional interfaces for payloads, and facilitate an early and orderly transition from the current expendable launch vehicles to the operational STS. Two SSUS-A's or four SSUS-D's with their spacecraft can be flown on a single Shuttle flight. The primary thrust of the SSUS program is to emphasize servicing the commercial spacecraft user's requirements.

The commercial development of the SSUS-A and SSUS-D by the McDonnell Douglas Corporation is proceeding on a schedule to meet anticipated launch requirements. Designs are being refined and system level and component level qualifications are being completed. Hardware is being manufactured and assembled for first flights. Three SSUS-D's have been successfully launched on the Delta expendable launch vehicle.

FY 1983 STS upper stages funding is required to complete the NASA portion of the two-stage IUS development and for modification for those NASA-unique planetary development activities.

Multimission and Payload Support Equipment

Multimission and payload support equipment consists of equipment required to integrate and check out payload elements, and a class of ground and flight hardware that will provide an interface between payloads and elements of the space transportation system (STS). These requirements can be satisfied more economically from a standard equipment inventory than by individual payload users. This reusable equipment is being developed to integrate, check out, transport, and operate a wide range of applications, science, and technology payloads.

Examples of this type of standardized equipment are:

(1) *Payload Transportation Equipment:* Intrasite payload equipment is being developed for use at the launch site to transport cargoes to and from the Shuttle orbiter. Ground and flight transportation equipment will also be used for cross-country transportation of payloads (regular and outsized) to and from the Kennedy Space Center and the Western Space and Missile Center.

(2) *Payload Specialist Station Equipment:* This equipment is required to conduct payload operations from the orbiter's aft flight deck. A concept utilizing existing technology has been defined and will satisfy the majority of payload functional command and display requirements, as well as mixed cargo integration and operations on early STS missions. This approach will minimize the need for payload-unique equipment and operational changeout time.

(3) *Mixed Cargo Support Equipment:* This equipment will provide maximum flexibility for mixing cargoes in the orbiter bay, as well as decreasing installation and checkout time. The use of identical

equipment for different payload configurations will allow simple crew interface and training. Examples of this equipment include standard cable harnesses which will allow command and data feedback simultaneously for up to four payloads in the orbiter cargo bay; and timing buffers which will provide various time signals to the Shuttle-attached payloads while they are active.

(4) *Cargo Integration and Test Equipment (CITE):* This equipment is used to integrate and checkout payload elements as they are assembled into a complete cargo to be flown on the space transportation system. CITE will verify the compatibility of the cargo to Shuttle interfaces, and assure that cargo elements do not interfere with each other.

(5) *Trace Gas Analyzer:* The trace gas analyzer system will perform in-flight monitoring of the aggregate "outgassing" constituents from payloads and metabolic sources in the Spacelab pressurized module. Its primary subsystems consist of a gas chromatographic column to detect the presence of an atmospheric substance and a mass spectrometer to measure the concentration of contaminants in the Spacelab.

(6) *Mission Kits:* The mission kits consist of standard and optional flight hardware designed to extend the capabilities of the payload and orbiter to support the mission as dictated by the payload requirements. Examples of these items are self-contained payload containers and nitrogen tanks.

In 1982, development will continue for mixed cargo hardware, cargo integration and test equipment, and transportation multimission support equipment. Initial testing and orbiter installation of multimission and payload support equipment such as the self-contained payload containers, mission kits, and payload specialist station will be completed, as will testing of the trace gas analyzer and the cargo integration and test equipment in the Vertical Processing Facility.

FY 1983 funds are required for the development, testing, and installation of the mixed cargo hardware and transportation multimission support equipment.

Mission Control Center (MCC) Upgrading (Level II)

Mission Control Center (MCC) upgrading (Level II) is the reconfiguration of the Johnson Space Center (JSC) Mission Control Center to support the STS operational flight schedule requirements. Flight-to-flight reconfiguration of the MCC must be automated to support the flight rate. MCC Level I, funded under the Shuttle development program, provides hardware and software to configure the MCC to support Shuttle development flights. During the operational era, the MCC will require additional flight control rooms, support rooms, hardware and software to accommodate any combination of two- and finally three-simultaneous orbiter flight operations (two real-time flights, one simulation, two pad tests) including Spacelab and IUS systems monitoring and flight control.

Upgrading the Mission Control Center (Level II) at JSC will continue in FY 1982 with accomplishment of the three-vehicle design review and full achievement of the single operations capability. Funds will be required for procurement of hardware including communication interface equipment.

Reconfiguration software development, as well as design, checkout, and testing of the trajectory, telemetry, and command software systems will continue.

Mission Control Center (Level II) upgrading will continue, completing elements of the basic upgrade, including the Payload Operations Control Center (POCC) interface in support of Spacelab. Substantial progress will be made toward the two-vehicle capability, necessary for flight rates above 12–15 per year which will occur after FY 1985.

Payload and Operations Support

The payload and operations support activity consists of two major areas of effort: Payload Operations Control Center (POCC) and orbital flight test (OFT) payload integration.

Orbital flight test payload integration provides for the analytical and physical integration of payloads launched on STS-3 amd STS-4, the two remaining orbital flight tests. One major NASA scientific payload (Office of Space Science-1) and several important pieces of test equipment will fly on STS-3. The latter includes the first Get-Away Special test cannister. A DOD payload is flying on STS-4.

Payload integration includes the unique planning, engineering, physical installation, and checkout of payloads and equipment that NASA must perform for each flight. Activities include defining and checking equipment interfaces, performing safety analyses, completing flight and ground simulations, as well as post flight data provision and equipment deintegration.

The POCC, located at the Johnson Space Center (JSC), provides for the command and control of Spacelab attached payloads that operate in the Shuttle cargo bay. It operates in conjunction with the JSC Mission Control Center. Funding is required for the acquisition of computers, displays, communication links, and associated software.

In FY 1982, development of hardware and software systems for the POCC at JSC will continue in order to allow payload command and control and some real-time data review and analysis during STS-2 and STS-3. Analytical integration activities associated with the orbital flight test payloads on STS-3 will be completed in FY 1982.

FY 1983 funds for payload integration will be used to complete post-flight activities.

FY 1983 funds for the POCC will be used to continue to work toward the completion of checkout and testing of the POCC in order to meet the readiness date required to support the operational flight schedule requirements.

Space Transportation Systems Operations Effectiveness

Effective utilization of the space transportation system (STS) is necessary to meet future operational requirements at the lowest possible cost. Objectives of operations effectiveness program are (1) reducing the cost and complexity of STS operations as the transition is made from development to full-scale operations, (2) defining alternative approaches to eventual institutionalization of the STS, and (3) developing strategies to insure maximum utilization of the STS.

The first objective will be met through both system improvements and procedural changes to achieve reduction of vehicle turnaround times, simplification of cargo processing and flight mission operations, improved risk management to make better use of system design margins within accepted safety/reliability limits, automation, and effectiveness-oriented management procedures. Analyses are being initiated in FY 1982 to identify and prioritize problem areas with emphasis on significant measurable benefit ratios and near term implementation.

FY 1983 funding will be used to develop approaches to solving the problem defined in FY 1982 studies and to begin implementation in selected areas.

DEVELOPMENT, TEST, AND MISSION SUPPORT/ENGINEERING AND TECHNICAL BASE

FISCAL YEAR 1983 FUNDING LEVEL

Research and test support	$29,900,000
Data systems and flight support	12,700,000
Operations support	32,000,000
Launch systems support	2,800,000
Total development, test, and mission support/engineering and technical base	77,400,000

In FY 1982, development, test, and mission support (DTMS) continues to provide the common engineering scientific and technical support required to conduct space transportation system (STS) research and development at the Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center, and the National Space Technology Laboratories. The DTMS effort is focused on four areas: research and testing, data systems and flight activities and operations and launch systems. These activities include engineering support for indepth technical examination of flight hardware and Shuttle related systems. DTMS also provides necessary equipment and supplies and performs alternative design, testing, and analysis in high technology areas of design and development.

Research and test support encompasses a broad spectrum of technical, engineering, scientific, reliability and quality assurance, and safety operations. Activities at the Johnson Space Center continue to certify and verify flight and ground hardware; refurbish and recertify flight hardware; conduct anomaly and resolution testing; and operate crew training stations. Marshall Space Flight Center activities support the Shuttle main engine static test firing exercises and integrated component testing as well as the qualification of the main propulsion system. Marshall Space Flight Center also supports refurbishment efforts for the solid rocket booster and provides flight evaluation of the external tank, solid rocket booster, main engine, and related systems.

In FY 1982, data systems and flight support efforts are associated with the ground-based data systems and general purpose data systems. The ground-based flight data systems effort supports the definition, design, implementation, and checkout of hardware and software modifications to the Johnson Space Center's Mission Control

Center. This includes the Shuttle Data Processing Complex which supports the Shuttle orbiter flight tests, as well as operation and maintenance of those facilities in preparation for operational mission support. Also included is the operation of the Johnson Space Center central data computation facililty Cyber System required to support centerwide activities in mission analysis, systems engineering development, and test functions for the Shuttle program.

Operations support provides for contractor effort and related supplies and equipment to operate and maintain on-site activities at the Johnson Space Center, the Marshall Space Flight Center, the Kennedy Space Center (until FY 1983), the National Space Technology Laboratories, and for off-site operations at the White Sands Test Facility.

Launch systems support provides for the development and test of the checkout and launch facilities and associated ground support equipment, as well as the technical services required to support the test, checkout, and launch of the Shuttle and payloads for the development test flights. Funding will provide for mechanical ground system activities involving operation and maintenance of launch systems and facilities for the Shuttle; maintenance and operation of the Kennedy Space Center electrical and mechanical utilities systems; and operation of technical shops and the precision cleaning laboratory which supports maintenance activities.

Starting in FY 1983, DTMS has been redefined and retitled Engineering and Technical Base (ETB). The redefined content provides only for the minimal core capability to sustain an engineering and development base to support various space transportation system programs. This core capability provides for a five day, one-shift operation of designated institutional research and development facilities except for the Johnson Space Center's computer complex which is based on a five day, two-shift operation. Any demands in excess of this one-shift base would be funded by the benefiting programs.

Research and Test Support

Beginning in FY 1983, Johnson Space Center will provide a five day, one-shift operation for the safety, reliability and quality assurance activities and for the engineering and development laboratories, such as the Shuttle Avionics Integration Laboratory, the Crew Systems Laboratory, the Electronic Systems Test Laboratory, and Water Immersion Facility. Present supporting activities at the Marshall Space Flight Center will be continued during FY 1983.

Data Systems and Flight Support

In FY 1983, data systems and flight support will provide a minimal core level of support based on a five day, two-shift operation of the central computer facility at the Johnson Space Center.

Operations Support

Funding will provide for the maintenance of technical facilities and equipment, chemical cleaning, engineering design, technical documentation and analysis, telecommunications, component fabrication, photographic support, and logistics support. Examples of specific services to be provided in 1983 include: (1) operation and maintenance of specialized electrical and cryogenic systems, and maintenance of test area cranes; (2) operation of shops to do metal refurbishing, anodizing, plating, stripping, and etching of selected items of in-house fabricated flight hardware; (3) cleaning of hoses, gauges, tubing, and related flight items that are fabricated in-house; (4) engineering, installation, operation, and maintenance of closed circuit fixed and mobile television required for support and surveillance of tests; (5) photographic services, including still and motion picture processing, an audio visual mission support; (6) fabrication of models, breadboards, and selected items of flight hardware; (7) technical documentation services, telecommunications, and graphics; (8) technical services in support of center operations including receipt, storage, and issue of research and development supplies and equipment and transportation services; and (9) management services in support of center operations, including data management, microfilming, and preparation of technical documentation.

In addition, FY 1983 funds will provide the basic level of support at the National Space Technology Laboratories for static test firing at the full power level (109% of rated power) of the main propulsion system and integrated component testing of the Space Shuttle main engine.

Launch Systems Support

The FY 1983 estimate supports a core of 65 manyear equivalents, a minimal manpower level, to maintain, develop, and capitalize on the research and development technologies available to enhance space flight hardware, ground processing, and support systems.

ADVANCED PROGRAMS

FISCAL YEAR 1983 FUNDING LEVEL

Advanced programs	$11,900,000

The principal objective of advanced programs is to provide technical and programmatic data for the definition and evaluation of potential future space programs and systems. Future systems requirements, cost, and capabilities are identified to provide the basis for selection of new flight systems. These efforts have continually provided the basis for new programs and systems, such as Apollo, Skylab, and the Shuttle. Subsystems studies and support development activities are conducted to demonstrate significant performance and reliability improvements and to reduce future program risks and development costs through the effective use of new technologies.

In 1982, the advanced programs effort will be focused on conducting system and subsystem development studies for the definition of space platforms for low and geosynchronous orbits and tether systems; the continued definition of alternative facility concepts to support the permanent presence of man in low Earth orbit; assembly and construction operations for large space systems and structures in orbit; the investigation of systems and subsystems concepts involving satellite services (i.e., placement, retrieval, and on-orbit maintenance and repairs); the definition of advanced transportation vehicle concepts including orbital transfer vehicles and Shuttle-derived launch vehicles; and the definition and analysis of satellite placement and retrieval systems remote from the orbiter. Completion of the alternative systems concept studies for the space platform will be accomplished.

In FY 1983, major emphasis will be placed on continuing studies, engineering investigations, and definition of mission options that will soon be possible because of the operational capability and flexibility of the space transportation system. These options will generally fall into three major categories: unmanned platforms in both low Earth orbit and geosynchronous orbit, a permanently manned facility in low Earth orbit, and various elements of orbital test and transportation for their support. In the unmanned platform area, design will be continued to define platform and power support systems to support user identified science and applications requirements. Alternative concepts will be developed for a permanent, Shuttle tended, manned facility in low earth orbit to support science, applications, and commercial research and development, as well as space operations and potential national security functions. The FY 1983 activities will focus on developing concepts to satisfy emerging science, applications, and commercial research and development requirements, and on performing trade-off studies on alternate approaches to space operations. For orbital test and transportation, the focus will be on large structures, satellite servicing, and advanced transportation options.

As part of the orbital test and transportation category, definition studies of life and crew support engineering activities required for extended orbital missions will be continued. Further investigations of potential tools and equipment for use in extravehicular activity and teleoperator operations will be carried out. Also, systems, subsystems, and engineering development studies to support deployable and erectable space structure activities will be continued. As part of construction operations, studies of assembly and repair of future structures in space will be continued as well as studies of extravehicular activity operations essential for satellite and platform maintenance. Concept and engineering development efforts on teleoperator systems to permit remote satellite servicing and studies will also be conducted to develop candidates for orbital testing of systems and end items that lie between Phase B and Phase C of the usual development approach in order to test feasibility and capability. Other planned activities for FY 1983 in this area include continuation of studies of advanced transportation to permit improved geosynchronous operations. As part of these efforts, emphasis will be placed on upper stages such as various approaches to a reusable orbital transfer vehicle, and the concept of a Shuttle-derived heavy lift launch vehicle.

SPACELAB

FISCAL YEAR 1983 FUNDING LEVEL

Spacelab	$113,200,000

The Spacelab is a major element of the space transportation system. The program is being carried out jointly by NASA and the European Space Agency (ESA) to provide a versatile, reusable space laboratory which will be flown to and from Earth orbit in the cargo bay of the Shuttle. The Spacelab will consist of a pressurized module and unpressurized pallet segments which can be used in various combinations to support mission requirements. It will permit researchers to conduct a wide range of experiments in a ground-type laboratory while operating in the unique environment of space.

Ten European nations, nine of which are members of the European Space Agency, are participating in the program. NASA and ESA are committed to bear the cost of their respective program responsibilities. ESA responsibilities include the design, development, production, and delivery of the first Spacelab, associated ground support equipment, and the Instrument Pointing System (IPS). NASA funding responsibilities include development of flight and ground support equipment not provided by ESA, development Spacelab operations capabilities, and procurement of additional flight and ground hardware needed to support NASA's Spacelab missions.

The first flight unit and one set of ground support equipment were delivered by ESA to NASA in the first quarter of FY 1982. These deliveries will increase Spacelab activities at the Kennedy Space Center involving the receipt, assembly, installation, checkout, and processing of the Spacelab hardware. Ground support equipment and facility verification testing will be accomplished certifying that the complex is ready for Spacelab launch processing. This work is performed for NASA by the Spacelab integration contractor who is also performing systems engineering, logistics planning, systems software preparation, and analytical experiment integration for the early Spacelab missions.

In FY 1982, the manufacture of the crew transfer tunnel will continue. The tunnel will link the Spacelab module to the Shuttle orbiter cabin. With the design complete, the fabrication of the verification flight instrumentation (VFI) equipment will continue, with deliveries beginning in FY 1982. The VFI includes sensors, electronic measuring and monitoring devices, and related flight and ground support equipment required to verify the performance of Spacelab subsystems and to monitor the environment to which payloads will be subjected. The procurement of initial spares for United States manufactured, but ESA developed, Spacelab hardware will continue in FY 1982.

Integration of the software for the Spacelab simulator will be completed in FY 1982. The utility kits, which serve as Spacelab-to-Shuttle orbiter mating hardware, will be delivered in FY 1982. The development of NASA provided ground support equipment will continue with additional deliveries to occur in FY 1982. During FY 1982, ESA engineering model pallets will be flown with experiments on two STS orbiter test flights. OSTA-1 was flown on STS-2 in November 1981 and OSS-1 will be flown on STS-3.

In early FY 1980, NASA signed a contract with ESA for the procurement of the second set of Spacelab hardware. Delivery of initial hardware, including racks and pallets, is to occur in FY 1982. The production and delivery of this follow-on hardware is planned to be completed in FY 1984.

FY 1983 funding is required to continue the procurement of the Spacelab follow-on hardware from ESA and to provide for a first flight in September 1983. The procurement includes a second set of flight elements and spares to support early Spacelab flights.

Work will continue on the crew transfer tunnel and the Spacelab simulator with FY 1983 funding. The first transfer tunnel is scheduled to be completed and the Spacelab simulator ready for crew training in FY 1983. The manufacture of ground support equipment will continue with additional elements to be delivered in FY 1983. The procurement of initial spares for United States manufactured, but ESA developed, Spacelab hardware will continue in FY 1983. FY 1983 funds will also be used to establish a repair capability to maintain Spacelab hardware during operations.

The Spacelab integration contractor will continue to perform the integration of the flight hardware for the first Spacelab missions. FY 1983 funds will provide for the preparation of procedures for processing and testing flight and ground hardware, as well as continued efforts in the areas of system engineering, logistics planning, and analytical integration for early missions.

SPACE TRANSPORTATION SYSTEMS (STS) OPERATIONS

FISCAL YEAR 1983 FUNDING LEVEL

Shuttle operations	$1,308,600,000
Upper stages operations	63,000,000
Payload support operations	34,500,000
Total space transportation system operations	1,406,100,000

Space transportation system operations will provide the transportation services and operational activities to bring about a more effective access to, and utilization of space for the expansion of human knowledge and for practical benefits on Earth. The space transportation system will provide for the delivery of free-flying payloads to low Earth orbit, facilitate the conduct of experiments using the Shuttle orbiter as a carrier vehicle for experiments mounted in Spacelab pressurized modules and on Spacelab pallets in the orbiter payload bay, deliver payloads to synchronous and other high energy orbits using the combined capabilities of the Shuttle and upper stages, retrieve free-flying payloads from Earth orbit, and provide on-orbit servicing of satellites.

The space transportation system operations activities integrate the Shuttle system, the Spacelab, and the upper stages into a versatile transportation system. Shuttle mission planning, procurement of recurring hardware and consumables, and support for operations involving launch, flight and recovery crews and related activities are well underway.

Upper stage operations provide for the procurement of upper stage hardware and related support necessary for orbital placement of spacecraft following low orbit deployment from the Shuttle orbiter. The upper stages include inertial upper stages and spinning solid upper stages.

Payload support operations provide for operational payload related hardware, services and launch site capability development required to meet a user's transportation requirements outside the scope of currently defined standard space transportation system services.

Shuttle operations—FY 1983 funding is required for continuation of procurement of raw materials and subassemblies for external tanks and solid rocket boosters as well as manufacture, assembly, and checkout of this flight hardware to support the currently planned flight rate for early operational missions. FY 1983 funding is also required for flight operations at the Johnson Space Center which includes mission operations planning, crew training, engineering support, and analytical integration for early operational flights in FY 1983 and subsequent. In addition, FY 1983 funding is required to conduct launch operations and vehicle refurbishment activities at the Kennedy Space Center.

Upper stage operations—Funding in FY 1983 is required to continue the procurement of major components and initial subsystem assembly of the upper stages to support NASA missions including the Tracking and Data Relay Satellite, Galileo, and the International Solar Polar Mission. Also funding is required for continuation of procurement of the spinning solid upper stage.

Payload support operations—Funding in FY 1983 is required to support ongoing payload integration analysis and implementation for currently scheduled launches. NASA payloads requiring significant support in FY 1983 include: Galileo, International Solar Polar Mission, Tracking and Data Relay Satellite, Space Telescope, and early Spacelab missions.

Shuttle Operations

Shuttle operations funding provides for the hardware and services necessary to conduct launch, on-orbit activities, recovery, and refurbishment of the Space Shuttle. This funding also provides for maintenance and repair of the Space Shuttle as well as replenishment spare hardware required during operational flights. The major elements of Shuttle operations include: procurement of external tanks; solid rocket boosters and propellants, vehicle ground operations for refurbishment and turnaround activities, mission operations and crew training, cargo and vehicle integration, procurement of spare ground and flight hardware including main engines, and, logistics, transportation and sustaining engineering.

Shuttle operations funding in FY 1983 provides for continuation of procurement of raw materials and subassemblies for external tanks and solid rocket boosters as well as the manufacture, assembly, checkout and delivery of these elements of flight hardware to support operational missions. Funding is also required for flight operation activities at the Johnson Space Center where preparations are conducted in the areas of mission operations, crew training, and analytical engineering and integration for early operational flights scheduled in FY 1983 and FY 1984. In addition, FY 1983 funding is required at the Kennedy Space Center to conduct vehicle and cargo ground operations related to launch preparation, launch and booster recovery, and total vehicle refurbishment for operational missions. Replenishment spares for ground support equipment are also provided by Shuttle operations in FY 1983. Major increases in FY 1983 above the current estimate for FY 1982 are the result of increased costs associated with the buildup in the number of operational flights.

Upper Stages Operations

Upper stages operations provides funding required to continue the procurement of major components and subsystem assemblies to support ongoing production of inertial upper stage (IUS) and spinning solid upper stage (SSUS) vehicles. The initial flight of the IUS vehicle will occur in the second quarter of FY 1983 in support of the first Tracking and Data Relay Satellite (TDRS).

FY 1983 upper stages operations funding provides for the phased procurement of upper stages consistent with the current manifest for operational missions, including the TDRS System. FY 1983 funding also provides for procurement of two additional two-stage IUS vehicles to support a 1985 Galileo launch and a 1986 International Solar Polar launch.

Payload Support Operations

Payload support operations provides the unique services required to prepare and launch NASA payloads. These services include unique integration hardware, loads and thermal analyses, spacecraft to upper stage analytical integration, and payload launch site support.

Funding in FY 1983 is required to support continuing and new payload services for NASA payloads. Major payloads receiving support in FY 1983 include Galileo, International Solar Polar Mission, Tracking and Data Relay Satellites, Spacelab 1 and 2, and Space Telescope.

3. EXPENDABLE LAUNCH VEHICLES, $42,800,000

FISCAL YEAR 1983 FUNDING LEVEL

Scout	....
Centaur	....
Delta	$42,800,000
Total expendable launch vehicles	42,800,000

The objective of the Expendable Launch Vehicles program is to provide for the centralized procurement of launch vehicles and launch support services for NASA's automated spacecraft missions, and for other agencies and organizations utilizing these systems and services on a reimbursable basis.

NASA's expendable launch vehicle transportation systems consist of the Scout, the Atlas Centaur, the Delta and the Atlas-F vehicles. This family of launch vehicles has been developed to support NASA's automated spacecraft launch requirements and, on both a cooperative and a reimbursable basis, to support other government, international, and commercial agencies and organizations. The expendable launch vehicle program includes the procurement of vehicle hardware, launch services, engineering and maintenance support, including the necessary reliability improvement of the launch vehicle, and the ancillary ground equipment. In FY 1983, all launches of the Scout, Atlas Centaur, and Atlas-F vehicles will be reimbursable.

Launches under this program are conducted from sites located at the Eastern Space and Missile Center (ESMC) formerly called the Eastern Test Range (ETR) in Florida, the Western Space and Missile Center (WSMC) formerly called Western Test Range (WTR) in California, the Wallops Flight Center in Virginia, and the San Marco Platform off the African coast near Kenya.

SCOUT

The Scout launch vehicle was initiated by NASA in 1959 with the goal of economically launching a wide variety of small scientific satellites, space probes, and re-entry experiments. The first Scout launch occurred in July 1960. In the ensuing 21 years, there have been 102 launches.

The Scout vehicle is the smallest launch vehicle employed by NASA. It is a four-stage, solid propellant launch vehicle. The vehicle is approximately 22.4 meters in length (73 feet) and the first stage booster has a diameter of 1.14 meters (3.75 feet). It is capable of placing a 180 kilogram (400 pound) payload in a 556 kilometer (300 nautical mile) orbit.

The Langley Research Center, located at Hampton, Virginia, has managed the Scout project since its inception. Scout vehicles are launched from the Western Space and Missile Center, California; from Wallops Island, Virginia; and from the San Marco Platform off the African coast near Kenya.

No appropriated funds are required for FY 1983 since the only NASA activity utilizing this vehicle system will be launching of a San Marco Cooperative Mission in 1983. Fiscal year 1982 funds are estimated to be sufficient to support the NASA effort in this cooperative program. However, this vehicle will be used to support DOD launches at least through 1985 on a reimbursable basis.

CENTAUR

This project provides for the procurement and launch of the Atlas booster stage and the Centaur upper stage. The Centaur is a high performance upper stage, which is the most powerful used by NASA for automated missions. It is being used with the Atlas booster for high energy missions to synchronous orbits. The Atlas Centaur vehicle is 40 meters (131 feet) in length and has a diameter of 3.1 meters (10 feet). The first Atlas Centaur launch occurred in 1962. In the ensuing 19 years, there have been 58 launches.

No appropriated funds are required for fiscal year 1983 since no NASA spacecraft are planned to be launched with this vehicle system. However, this vehicle will be used for INTELSAT launches at least through 1984, for which NASA will be reimbursed.

DELTA

FISCAL YEAR 1983 FUNDING LEVEL

Delta	$42,800,000

The Delta launch vehicle is the most widely used vehicle in NASA's expendable launch vehicle family. Since its first use in 1960, this vehicle has been utilized in 158 launches and has experienced a success record of over 92 percent. It is presently operational with two and three stage configurations. The first stage is an elongated Thor booster with three, six, or nine strap-on solid motors for thrust augmentation.

The second stage Delta, which provides a multiple restart capability, uses an inertial guidance system for guiding the first stage booster and the second stage Delta. With the use of a Payload Assist Module (PAM/SSUS-D) solid motor attached to the spacecraft, this vehicle is capable of placing a 1,100 kilogram payload (2,400 pounds) into a synchronous transfer orbit. This vehicle in its three-stage configuration is approximately 35 meters in length (115 feet) and has a diameter of 2.44 meters (8 feet).

The fiscal year funding will be used to continue the Delta launch, vehicle procurements initiated in prior years to support Landsat-D and AMPTE NASA spacecraft requirements. Funds are also required for technical and engineering support to sustain vehicle test and checkout and launch operations, and to support maintenance of launch facilities and ground equipment.

This vehicle system, planned to be operational at least until 1985, is the most utilized of our current vehicles. It is being used to support backup Shuttle user requirements, on a reimbursable basis, for launching missions for other United States Government, commercial, and international mission users. Development of an uprated second stage capable of placing a 1,270 kilogram payload (2,800 pounds) into a synchronous transfer orbit is continuing on schedule. This new vehicle configuration will be launched for the first time in mid-1982 when it will boost the NASA Landsat-D mission into orbit.

4. PHYSICS AND ASTRONOMY, $463,500,000

FISCAL YEAR 1983 FUNDING LEVEL

Space telescope development	$137,500,000
International solar polar mission development	21,000,000
Gamma ray observatory development	34,500,000
Shuttle/Spacelab payload development and mission management	81,400,000
Explorer development	34,300,000
Mission operations and data analysis	77,400,000
Research and analysis	39,200,000
Suborbital program	38,200,000
Total physics and astronomy	463,500,000

The major objective of the Physics and Astronomy program is to increase our knowledge and understanding of the solar-terrestrial space environment and of the origin, evolution, structure, and composition of the universe, including the Sun, the stars, and the other celestial bodies. Space-based research is being conducted to investigate the physics, chemistry, and the transport processes occurring in the Earth's magnetosphere, ionosphere, and atmosphere, and the responses of the transport processes to solar phenomena and variability; the structure and dynamics of the Sun and its long- and short-term variations; cosmic ray, x-ray, ultraviolet, optical, infrared, and radio emissions from stars, interstellar gas and dust, pulsars, neutron stars, quasars, blackholes, and other celestial sources; and the laws governing the interactions and processes occurring in the universe. Many of the phenomena being investigated are not detectable from ground-based observatories because of the obscuring or distorting effects of the Earth's atmosphere.

To achieve the objectives of the Physics and Astronomy program, NASA employs theoretical and laboratory research; aircraft, balloon, and sounding rocket flights; Shuttle/Spacelab flights; and free-flying spacecraft. Research terms involved in this program are located at universities, industrial laboratories, NASA field centers, and other government laboratories.

The scientific information obtained and the technology developed in this program are made available to the scientific communities for application to and the advancement of scientific knowledge, education, and technology.

The physics and astronomy missions undertaken to date have been extraordinarily successful. Although the last two of the highly successful High Energy Astronomy Observatories (HEAO's) have ceased operation in the last year, four missions continue to bring us a rich harvest of data—the International Ultraviolet Explorer (IUE), the Solar Maximum Mission (SMM), the International Sun-Earth Explorer (ISEE), and the Dynamics Explorer (DE) missions. The SMM has given us a new picture of the sequence of events that occur in a flare of the Sun; it has also measured nuclear processes that accompany these energetic events. After observing a large number of flares, data from the Solar Maximum Mission have contributed significantly to the development of a new model of how solar flares occur.

The explorer satellites are generally relatively low cost missions whose origin dates back to the beginning of our country's space program. One of the newest in the space physics series is the Dynamics Explorer, launched August 3, 1981. This two-spacecraft mission is studying the coupling between the magnetosphere at high latitudes and the ionosphere by making simultaneous measurements from the two regions of space. Already, scientists are correlating auroral images taken at the same time electric fields were measured and plasma waves observed in the magnetosphere. International Ultraviolet Explorer results include recent observations of a binary star system from which the flow of gas from one star was mapped as it wound around its companion white dwarf and left the system entirely. The International Sun-Earth Explorer program continues to return data on the effect of the solar wind on the boundary between the solar wind and the Earth's magnetosphere. With the Sun at its peak of activity, the last two years have been an especially interesting time, while the solar wind has buffeted the magnetosphere with great force.

Major accomplishments during 1981 also included the completion of development activities for the Solar Mesosphere Explorer (SME) leading to a launch on October 6, 1981. The SME is investigating the global distribution of ozone in the stratosphere to determine how this distribution changes with the seasons of the year, and to understand how solar activity affects the ozone distribution in the Earth's atmosphere.

In FY 1982, development activities will continue on the Space Telescope which will allow optical and ultraviolet research for decades. Initial design and development activities will be largely completed and hardware development for the Gamma Ray Observatory will be started leading to a launch in late 1988. Work will also continue on instruments which will be flown on the International Solar Polar Mission.

Development will continue in FY 1982 on the Active Magnetospheric Particle Tracer Explorer, a cooperative program with the Federal Republic of Germany, leading to a launch in 1984. Development on the Infrared Astronomical Satellite, a cooperative effort with the Netherlands and the United Kingdom to carry out a detailed all-sky survey of infrared sources, will be essentially completed leading to a launch in late 1982. Similarly, development efforts will be completed on the San Marco–D mission, a cooperative mission with Italy, and on the Cosmic Ray Isotope Experiment, both scheduled for launch in 1982. Development will be initiated on the Cosmic Background Explorer leading to a launch in 1987. This mission will carry out a definitive all-sky mapping of the infrared and microwave radiation which comes from the remains of the "Big Bang." The data obtained will provide information on the nature of the earliest events in the universe.

Besides receiving data from operating spacecraft, suborbital observations are conducted from balloons, sounding rockets, and high-flying aircraft that carry instruments above most of the atmosphere. Development is also continuing on instruments which will be flown on the Shuttle orbital flight tests and later Spacelab missions. Significant progress has been made in the preparation of the Spacelab–1 and –2 missions which are operational demonstration flights of the Spacelab hardware developed by the European Space Agency.

FY 1983 funding will support continued development work on the Space Telescope, the Gamma Ray Observatory, the Active Magnetospheric Particle Tracer Explorer, and on the Cosmic Background Explorer and experiments for the International Solar Polar Mission. FY 1983 funding will support continued mission management efforts for all NASA Spacelab payloads. The FY 1983 funds will provide for continued instrument development and mission management for Spacelabs–1 and –2, and for instrument development, including the Solar Optical Telescope, and mission management activities for future Spacelab missions.

FY 1983 mission operations and data analysis activities will focus on the operation and analysis of data from satellites which are producing valuable scientific data. These satellites include the Dynamics Explorer, the Solar Mesosphere Explorer, the Infrared Astronomical Satellite, the Solar Maximum Mission, the International Ultraviolet Explorer, and the International Sun-Earth Explorers. In addition, FY 1983 funding will support the analysis of the data acquired by the highly successful High Energy Astronomy Observatory missions, preparations for science operations for the Space Telescope, and initial activity to provide the capability for maintaining and refurbishing the Space Telescope after launch, including the development of new scientific instruments. Funding in FY 1983 will also support preparations for carrying out retrieval/repair of the Solar Maximum Mission spacecraft and instruments with the objective of returning the spacecraft to full operational status.

The FY 1983 suborbital program will provide for continuing scientific investigation through balloon, aircraft, and sounding rocket flights.

FY 1983 research and analysis funding will support a broad range of efforts to provide the research and technology base required for well-conceived and defined future programs. In the supporting research and technology program, tasks critical to maintaining a firm scientific base for physics and astronomy will continue. In the area of advanced technology development, design and definition will be carried out for potential future missions, including Shuttle/Spacelab payloads and free-flying spacecraft. The data analysis activity will include operation of the National Space Science Data Center and general data analysis activities.

SPACE TELESCOPE DEVELOPMENT

The Space Telescope will make a major contribution to understanding the stars and galaxies, the nature and behavior of the gas and dust between them, and the broad question of the origin and scale of the universe. Operating in space above the atmospheric veil surrounding the Earth, the Space Telescope will increase by several hundredfold the volume of space accessible for observations. With its significant improvements in resolution and precision in light sensitivity and in wavelength coverage, the Space Telescope will permit scientists to conduct investigations that could never be carried out using ground-based observatories due to the obscuring and distorting effects of the Earth's atmosphere.

The Space Telescope will enhance the ability of astronomers to study radiation in the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will record greater detail about the objects under study. It will make possible observation of objects so remote that the light will have taken many billions of years to reach the Earth. As a result, we will be able to look far into the distant past of our universe. The Space Telescope will also contribute significantly to the study of the early state of stars and the formation of solar systems, as well as to the observation of such highly-evolved objects as supernova remnants and white dwarf stars. With the Space Telescope, we may be able to determine the nature of quasars and the processes by which they emit such enormous amounts of energy, and it may also be possible to determine whether some nearby stars have planetary systems.

The Space Telescope will be an automated observatory, delivered into orbit by the Space Shuttle. Data from its scientific instruments will be transmitted to Earth via the Tracking and Data Relay Satellite System. The Space Telescope design will permit in-orbit maintenance, repair, and retrieval by the Space Shuttle for return to Earth, refurbishment, and reuse.

During FY 1981, continued progress was made in the design and development of the space telescope. Polishing was completed on the flight and backup primary mirrors, as well as on the secondary mirror. The flight primary and secondary mirrors will be coated in early FY 1982. Critical design reviews were completed on the scientific instruments. All flight optical benches for the instruments have been fabricated and tested. A systems interface review for all elements of the program was held in 1981. Approximately 65-70 percent of the drawings for the support systems module were completed.

FY 1982 activities continue to support detailed design, development, and manufacture of the optical telescope assembly, the support systems module, and the scientific instruments. Assembly and test of the scientific instruments will be initiated in FY 1982. Assembly of the optical telescope assembly subsystems will continue. In addition, the critical design review for the support systems module will take place in FY 1982, and manufacturing will be initiated.

The FY 1983 funding will support the continued fabrication, assembly, and testing activities of the optical telescope assembly, the scientific instruments, and support systems module. Assembly of the scientific instruments will be completed and verification testing will be conducted. Assembly and test of the optical telescope assembly will be completed, as well as fabrication and assembly of the support systems module leading to initiations of assembly of the total Space Telescope in the first half of 1984.

INTERNATIONAL SOLAR POLAR MISSION DEVELOPMENT

The International Solar Polar Mission is a joint NASA and European Space Agency (ESA) mission designed to obtain the first view of the solar system from a new perspective—a view from far above the plane in which the planets orbit the Sun's equator. The mission will aid in the study of the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, and hence allow us to gain insight into the effects of solar activity on the Earth's weather and climate.

In FY 1981, restructuring of the International Solar Polar Mission program to a single-spacecraft mission was implemented. Although the United States is no longer developing a spacecraft for this mission, United States participation remains substantial. Of the nine investigations to fly on the remaining European spacecraft, five have United States principal investigators and three of the four European investigations have United States co-investigators. In addition, the United States will provide the radioactive thermal power generator, spacecraft auxiliary propulsion system ("kick" stage), launch services, and tracking and data acquisition for the mission.

In FY 1983, development work will continue on the science instruments which will be flown on the single International Solar Polar Mission spacecraft. FY 1983 funding will also support continued development of an auxiliary propulsion system (kick stage and interstage) to accommodate the launch on the Shuttle/inertial upper stage in 1986.

GAMMA RAY OBSERVATORY DEVELOPMENT

The objective of the Gamma Ray Observatory mission is to measure gamma ray radiation from the universe and, thus, to explore the fundamental physical processes powering it. Certain celestial phenomena are accessible only at gamma ray energies. The observational objectives of the Gamma Ray Observatory are to search for direct evidence of the synthesis of the chemical elements; to observe high energy astrophysical processes occurring in supernovae, neutron stars and black holes; to locate gamma ray burst sources; to measure the diffuse gamma ray radiation for cosmological evidence of its origin; and to search for unique gamma ray emitting objects.

Gamma rays represent one of the last frontiers of the electromagnetic spectrum to be explored because the required technology has only recently been developed. The low flux levels of gamma ray quanta, and the high background they produce through their interaction with the Earth's atmosphere, coupled with the demand for better spectral, spatial, and temporal resolution of source features, combine to require that large gamma ray instruments be flown in space for a prolonged period. Gamma rays provide unique information on the most intriguing astronomical objects yet discovered, including quasars, neutron stars, and black holes. Astronomy is now to the point where our understanding of these objects is being seriously impaired by lack of data in the gamma ray region of the spectrum. Comprehensive research in gamma ray astronomy has consistently been given high priority by the science community.

The Gamma Ray Observatory will be launched by the Space Shuttle. The spacecraft is designed to accommodate several gamma ray instruments. It is planned that the majority of the instruments will have their principal axis pointing in the same direction, and the spacecraft will point these instruments in a fixed direction in space for long periods (hours to weeks).

Fiscal year 1981 activities including the selection of the mission system contractor, initiation of spacecraft design, confirmation of the scientific instruments, and initiation of the instrument development contracts. In fiscal year 1982, procurement was initiated on long-lead items, and the design of the scientific instruments and spacecraft will be completed. Configuration drawings, resulting from studies of instrument placement and thermal requirements, have been completed. Preliminary interfaces with the scientific instruments, the Space Shuttle, and the Tracking and Data Relay Satellite System have been defined.

During fiscal year 1983, critical design reviews on the scientific instruments will be completed. Planning and tooling for the spacecraft structure and appendages will be initiated, as well as development buildup for the spacecraft and instrument hardware. In addition, the development of procedures for spacecraft integration and test will be initiated.

SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT

The objectives of the Shuttle/Spacelab payload development and mission management are to acquire new knowledge in the disciplines of physics and astronomy and to manage the mission planning and execution of the complete NASA Spacelab payload program. The funding provides for the development of all physics and astronomy Spacelab experiments, the system management and engineering development of the flight equipment and software, the payload specialist support, the physical integration of the payload with the Spacelab system, the operation of the payload during flight, the dissemination of data to experimenters, and the analysis of physics and astronomy flight data.

Instruments to be flown on three missions primarily dedicated to physics and astronomy science are now under development. The OSS-1 pallet will be flown on a Shuttle orbital flight test mission in 1982. The OSS-1 mission consists of six instruments that will gather solar physics data, evaluate the Shuttle environment, and provide data on thermal control technology. Integration and test of the OSS-1 payload is now nearing completion. Spacelab-1, which will consist of a pressurized Spacelab module and a pallet, is scheduled for flight in 1983. The objectives of Spacelab-1 are to demonstrate the capabilities of the Spacelab system and to obtain multidisciplinary scientific data with emphasis on atmospheric and space plasma physics. In 1982, the Spacelab-1 payload will be integrated with the Spacelab equipment. Spacelab-2, an all-pallet configuration, is scheduled to fly in 1984. The objectives of Spacelab-2 are to verify the Spacelab igloo and pallet systems and to obtain scientific data, with emphasis on astrophysics and solar physics. The instrument pointing system, developed by the European Space Agency, will be used for the first time on the Spacelab-2 mission. During fiscal year 1982, Spacelab-2 mission management activities and instrument development will continue.

The OSS-3 mission is also under development leading to a launch scheduled for 1985. OSS-3 is a Spacelab pallet payload of three ultraviolet telescopes that will carry out ultraviolet imaging, spectrophotometry and polarimetry at resolutions and sensitivities previously unavailable. This payload will allow unique new scientific investigations of a broad range of objects from nearby comets and planets out to the most distant quasars. Data gathered by the OSS-3 mission will be used to define and direct future Space Telescope observations. The OSS-3 science instruments will be reflown on the Shuttle during the period of Halley's Comet for unique scientific observations of the comet from the near-Earth orbital environment.

Several physics and astronomy instruments are under development for flights on the Shuttle/Spacelab in 1984 and subsequent years. Two general types of instruments are under development: principal investigator instruments and multiuser instruments. Principal investigator instruments are for a specific scientific investigation by a single investigator who may have co-investigators. Multiuser instruments have a broad scientific capability, can accommodate a number of principal investigator-furnished focal plane or ancillary instruments, and have a large user community. In 1982, the development contractor for a multiuser instrument, the Solar Optical Telescope, will be selected. Another multiuser instrument under definition is the Shuttle Infrared Telescope Facility which will be used to conduct high resolution studies of selected celestial infrared objectives. These studies will provide valuable insight into many questions of modern astrophysics, including the early stages of star formation and the later stages of star evolution, the unusually high energy output of the nuclei of certain galaxies and quasars and the early evolution of galaxies and the universe. Definition and development schedules of physics and astronomy instruments are phased to form scientifically focused payloads. Instruments, both those that are now being developed for OSS–1, Spacelab-1, and Spacelab-2, as well as the principal investigator and multiuser instruments, will be reused on future Shuttle/Spacelab missions, thereby significantly increasing the scientific value of the original investment.

Part of the Shuttle/Spacelab payload development and mission management activities involve the development of several systems necessary for the optimum use of the Shuttle/Spacelab system by all users. At the Kennedy Space Center, a system is being implemented to assemble experiments with Spacelab hardware to form an actual mission payload and subsequently to test the integrated system. An annular suspension pointing systems will significantly enhance the quality of scientific data from mounted instuments and will allow more efficient use of the Spacelab provided instrument support systems. This pointing system will be used for both principal investigator and multiuser instruments.

In FY 1983, mission management of the ongoing NASA Shuttle/Spacelab missions will continue. Mission management for the nonphysics and astronomy missions involves all the Spacelab payload functions except instrument or experiment development and data analysis. Included among the activities outside the physics and astronomy disciplines are mission management for the space applications, technology and life sciences programs.

The FY 1983 funding is also required for analysis of data from the OSS–1 flight. OSS–1 will be flown on a Shuttle orbital flight test in 1982. Efforts will be completed on Spacelab-1 leading to a launch in 1983. Spacelab-2 integration and test activities will be continued in FY 1983 leading to a launch in 1984. Instrument development for the OSS–3 flight will be continued as well as development efforts on the Solar Optical Telescope.

EXPLORER DEVELOPMENT

The explorer program provides the principal means of conducting astronomical studies and long-term investigations of solar physics and of the near-Earth interplanetary environment having limited, specific objectives and not requiring major observatories. Included in the present program are missions to study atmospheric and magnetosphere physics; the several magnetospheric boundaries; interplanetary phenomena; and x-ray, ultraviolet, and infrared astronomy. Studies are conducted to define future high priority science explorer missions. NASA engages in cooperative missions with other Federal agencies and other nations whenever such cooperation will assist in achieving NASA objectives.

Solar terrestrial and atmospheric explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide variety of satellites in orbits extending from the very lowest reaches of the upper atmosphere, to the interplanetary medium beyond the Earth's magnetosphere. Efforts in FY 1982 include completion of development activity for the San Marco–D (low orbit) mission and continuation of development on the Active Magnetospheric Particle Tracer Explorer. The San Marco-D mission, a cooperative project with Italy, will include a group of United States experiments to study the relationship between solar activity and the Earth's meteorological phenomena. The Active Magnetospheric Particle Tracer Explorer (AMPTE), a cooperative project with the Federal Republic of Germany, will involve the use of two spacecraft, one designed and built in the United States, to study the solar wind at the subsolar point and to identify particle entry windows, energization processes and transport processes into the magnetosphere. The two Dynamics Explorer spacecraft, launched in August 1981, are already providing valuable data on interactive processes of the magnetosphere, ionosphere, and upper atmosphere. The Solar Mesosphere Explorer, launched in October 1981, is investigating the global distribution and production of atmospheric ozone, and variability in solar ultraviolet radiation.

Astrophysics explorers have been instrumental in conducting the first astronomical sky surveys in the gamma ray, x-ray, ultraviolet, and low frequency radio regions of the electromagnetic spectrum. A major effort underway in FY 1982 is the completion of satellite integration and testing activities on the Infrared Astronomical Satellite, which is scheduled to be launched in late 1982. This satellite is expected to record precise flux levels and locations of over a million infrared sources in the universe. A smaller development effort which is nearing completion is the Cosmic Ray Isotope Experiment. This payload, which will be launched in 1982 on a Department of Defense spacecraft, will be used to study galactic cosmic rays, as well as nuclei accelerated from solar flares, in order to shed light on models of nucleosynthesis and to identify probable sources of cosmic ray nuclei.

In addition, development will begin in late FY 1982 on the Cosmic Background Explorer (COBE). COBE will carry out a definitive all-sky exploration of the diffuse cosmic background radiation of the universe between the wavelengths of 1 micrometer and 13 millimeters. The detailed information this mission will provide on the spectral and spatial distribution of low energy background radiation is expected to yield significant insights into basic cosmological questions of the origin and evolution of the universe.

FY 1982 funding will also support definition studies for future candidate explorer missions including the Extreme Ultraviolet Explorer and the X-Ray Timing Explorer.

FY 1983 funding will provide for continued development activity on the AMPTE and COBE missions. FY 1983 funding will also provide for design and definition studies for future candidate missions, including the Extreme Ultraviolet Explorer and the X-Ray Timing Explorer. The Extreme Ultraviolet Explorer, the next candidate Explorer mission, is approaching readiness for a development start. This mission will carry out the first detailed all-sky survey of ultraviolet radiation between 100 and 900 angstroms—a hitherto unexplored portion of the electromagnetic spectrum.

MISSION OPERATIONS AND DATA ANALYSIS

The purpose of the mission operations and data analysis effort is to conduct operations and to analyze data from the physics and astronomy satellites after launch. This program also supports the continued operation of a number of spacecraft, after their originally planned objections have been achieved, for purposes of conducting specific investigations that have continuing, high scientific significance. The funding supports the data analysis activities of the many investigators at universities and other research organizations associated with astrophysics and solar terrestrial operational satellite projects. Actual satellite operations, including operation control centers and related data reduction and engineering support activities are typically carried out under a variety of mission support or center support contracts.

Several explorer spacecraft remain operational and are providing valuable data. The International Ultraviolet Explorer and International Sun-Earth Explorers continue to perform well, with very productive guest investigator programs. Mission operations and data analysis will continue for these missions through FY 1982, as well as for the recently launched Dynamics Explorer and Solar Mesosphere Explorer spacecraft.

In addition to the normal support required for mission operations, the Space Telescope program encompasses several unique aspects which must be provided for well in advance of launch. The Space Telescope is designed for operation for more than a decade, based on in-orbit maintenance, recovery, refurbishment, and relaunch and in-orbit changeout of the scientific instruments. During the operational period, the Space Telescope will be used primarily by observers selected on the basis of proposals submitted in response to periodic solicitations. NASA has determined that the most efficient and scientifically satisfactory approach to science operations will involve establishment of an independent Science Institute which will operate under a long-term contract with NASA. While NASA will retain operational responsibilities for the observatory, the institute will implement NASA policies in the areas of planning, management, and scheduling of the scientific operations of the Space Telescope.

FY 1983 funds will provide support for the basic mission operations and data analysis activities for the Dynamics Explorers, the Solar Mesosphere Explorer, and the Infrared Astronomical Satellite; data analysis activity for the Cosmic Ray Isotope Experiment which is scheduled for launch on an Air Force spacecraft in 1982; extension of operations and data analysis activity for the International Ultraviolet Explorer, the International Sun-Earth Explorers 1, 2, and 3; and support for continued analysis of the extensive data obtained by the High Energy Astronomy Observatory missions. FY 1983 funding will also support the continued operation and data analysis activities of the Solar Maximum Mission (SMM), as well as the continuation of preparations for science operations of the Space Telescope, including development of the Space Telescope Institute and the science operations ground system. The FY 1983 funding is also required for initiation of design and fabrication of support equipment and orbital replacement units to be used for Space Telescope maintenance and refurbishment.

RESEARCH AND ANALYSIS

This program provides for the research and technology base necessary to define, plan, and support flight projects. Preliminary studies to define missions and/or payload requirements are carried out, as are theoretical and ground-based supporting research and advanced technology development (ATD). Activities included are supporting research and technology (SR&T), ATD, and data analysis.

Supporting Research and Technology (SR&T)

The objectives of supporting research and technology are: (1) to optimize the return expected from future missions by problem definition, development of advanced instrumentation and concepts, and sound definition of proposed new missions; (2) to enhance the value of current space missions by carrying out complementary and supplementary ground-based observations and laboratory experiments; (3) to develop theories to explain observed phenomena and predict new ones; and (4) to strengthen the technological base for sensor and instrumentation development and to conduct basic research necessary to support our understanding of astrophysics and solar terrestrial relationships.

Research is supported in several disciplines of space physics and astronomy. The work in space physics is largely devoted to tasks related to the physics of the Earth's space environment and comparative studies of other planetary environments, including the study of Sun-Earth environmental factors. In addition, the Earth's environment contains the most accessible space plasma in which we study processes of importance elsewhere in the universe. The work in solar and heliospheric physics involves studies of the solar atmosphere and the influence of the Sun on interplanetary phenomena. Research supported in astronomy and astrophysics involves studies of stars, galaxies, interstellar and intergalactic matter and cosmic rays. The development of new instruments, laboratory and theoretical studies of basic physical processes, and observations by ground-based and balloon-borne instruments are also supported. Results achieved in the SR&T program have a direct bearing on future flight programs. For example, the development of advanced X-ray and ultraviolet astronomy imaging devices under this program will enable spacecraft in high Earth orbits to watch the flow of energy into the auroral zones.

A major activity in SR&T is the solar terrestrial theory program which provides for theoretical investigations of the predominantly plasma physics processes important to solar physics and the solar terrestrial environment. The intent of the program is to enhance and assure the systematic development of scientific investigation of solar system plasmas and for this to play a vital role in the planning of future missions and research efforts.

The SR&T program carries out its objectives through universities, nonprofit and industrial research institutions, NASA centers, and other government agencies. Current emphasis is being placed on studies for advanced instrumentation to increase both sensitivity and resolution. Feasibility and scientific definition studies are being conducted on Gravity Probe-B (GP–B), a mission to carry out an experimental test of Einstein's general theory of relativity in which measurements would be obtained of the relativistic precession of an extremely stable, cryogenic gyroscope in Earth orbit.

Advanced Technological Development

The advanced technological development activities support detailed planning and definition of new physics and astronomy missions including Shuttle/Spacelab missions. ATD activities assure that advanced missions address the scientific questions most important to the evolution of knowledge in the field, and that those missions use the appropriate technology and techniques. Funding is applied to the definition and preliminary design for specific missions or subsystems and elements critical to eventual mission development, in order that technical readiness and resources may be better defined before the missions are proposed for implementation.

Candidate missions for the 1980's and early 1990's that require ATD activities include the Origin of Plasmas in the Earth's Neighborhood (OPEN), the Advanced X-ray Astrophysics Facility (AXAF), the Starprobe, and the Solar Internal Dynamics Mission (SIDM). The OPEN project will study systematically the origin, storage, transport, and loss of plasmas in the Earth's environment from input by the solar wind and ionosphere to loss in the atmosphere. The mission will assess the importance to the terrestrial environment of variations in energy input to the Earth's atmosphere caused by geospace processes. The AXAF will study stellar structure and evolution, active galaxies, clusters of galaxies and cosmology. The AXAF's 1.2 meter class imaging X-ray telescope is planned to have sensitivity approximately 20 times that of HEAO-2. The Starprobe mission will perform detailed scientific observations of the Sun from a highly elliptical orbit whose aphelion will be within three solar radii of the Sun's surface. The Solar Internal Dynamics Mission (SIDM) will observe the oscillations visible on the Sun and use the data obtained to investigate the dynamics of the Sun's interior.

Major Spacelab payloads requiring advanced technological development support include the following multiuser facilities: the Shuttle Infrared Telescope Facility (SIRTF), a cryogenically-cooled telescope which will carry out high sensitivity infrared observations; the Pinhole/Occulter Facility, a coded mask and detector for imaging hard X-rays; and the Shuttle Ultraviolet/Optical Telescope (STARLAB), a meter-class ultraviolet/optical facility which will be used for high angular resolution imaging investigations of sources that have too great an angular extent to be observed efficiently with the Space Telescope. During fiscal year 1982, major emphasis is being given to definition of the OPEN and AXAF missions. In addition, further definition of Spacelab instruments and facilities will continue, including detailed description of instruments, payload configurations and operational requirements.

Data Analysis

The acquisition, analysis, and evaluation of data represents the primary purpose of the laboratory, balloon, rocket, and spacecraft activities. While a considerable amount of analysis is done during the prime project phase, experience has shown that considerably more time is generally required to reap the full benefit from these programs. The full benefit can be realized only when the data is correlated with other projects, when detailed cause-and-effect studies are made with data sets from other sources, when very long-term (e.g., one solar cycle) effects can be studied using complementary sets of data, and when new ideas that originate from the results of the initial analysis can be tested.

For example, astronomical image processing facilities have been developed to take advantage of high technology developed under the Landsat and planetary programs. This technology allows astronomers to obtain a maximum amount of information from the data they obtain from standard photographic emulsions and more advanced imaging techniques such as the charge-coupled devices (CCD's) now being ground-tested for eventual use on the Space Telescope.

Support of the operation of the National Space Science Data Center (NSSDC) is also provided under this program. The NSSDC, located at the Goddard Space Flight Center, was established to serve as a central repository and clearing house for scientific data resulting from space investigations. The NSSDC is now in a stage of transition from a repository to a facility when correlative research can be accomplished using data sets from many sources, including active spacecraft. The Satellite Situation Center at NSSDC computes the expected positions of operational spacecraft so that data acquisition and analysis efforts can be coordinated at times when several spacecraft are favorably situated for correlative geophysical studies.

During fiscal year 1983, the supporting research and technology program will support those tasks which contribute to maintaining a firm base for a viable physics and astronomy program. Emphasis will be placed on infrared detector development and on expansion of technology activities related to large X-ray mirrors, advanced X-ray detectors, gamma ray spectrometers, and instrumentation. Feasibility and scientific definition studies will be conducted on future potential candidate missions such as Gravity Probe-B. Emphasis will also be placed on the development of a large area electrographic camera for astronomical use, and on the continued development of large array multichannel plate and intensified charge-coupled imagery devices.

In the area of solar physics, activities will support the Solar Maximum Mission, especially through theoretical studies of high energy phenomena. New thrusts will be initiated in the development of advanced generation instrument concepts, especially for the extreme ultaviolet and X-ray wavelength, and for analyzing the internal structure of dynamics of the solar interior. In the area of theoretical studies, investigations will be carried out by concentrating groups of theorists in the fields of solar, interplanetary, magnetospheric, ionospheric, and atmospheric physics in a coordinated program aimed at the understanding of the detailed behavior of each of these components of the solar terrestrial relationship and their interrelationships.

Emphasis in the data analysis activities, to be carried out at universities and government research centers, will be placed on correlative studies involving data acquired from several sources (spacecraft, balloons, sounding rockets, research aircraft, and ground observatories). Fiscal year 1983 funds will also support the operation of the National Space Science Data Center at the Goddard Space Flight Center. The fiscal year funding will also allow for further system definition studies, and instrument definition for investigations selected for the Origin of Plasmas in the Earth's Neighborhood mission. In addition, funding will support studies on the Advanced X-ray Astrophysics Facility, the Starprobe and the Solar Internal Dynamics Mission. Definition studies will be continued to assure the technological and scientific readiness of candidate future missions. Fiscal year 1983 funding is also required to support definition of new Spacelab payloads as well as those currently under study.

SUBORBITAL PROGRAMS

Sounding Rockets

The sounding rocket program provides versatile, relatively low cost research tools that complement the capabilities of balloons, aircraft, free-flying spacecraft and the Space Shuttle in all the space science disciplines, including the study of the Earth's ionosphere and magnetosphere, space plasma physics, steller astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a domestic and an international cooperative basis.

A primary objective of the sounding rocket program is to conduct a coordinated research program with flight requirements that cannot be met by vehicles with different performance characteristics. Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Specific areas of study include the nature, characteristics, and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurorae and the coupling of energy into the atmosphere; and the nature, characteristics, and spectra of radiation of the Sun, stars, and other celestial objects.

Additionally, the sounding rocket program provides the physics and astronomy program with the means for flight testing instruments and experiments being developed for later flight on the Shuttle/Spacelab and space probes; and for calibrating and obtaining vertical profiles in concert with current orbiting spacecraft.

In FY 1981, 48 rockets were launched from seven locations in the United States, Canada, Sweden, Norway and Antarctica. These rockets supported the research activities of about 50 groups from universities, private industry, NASA field centers, other government agencies and foreign space organizations.

During FY 1981, sounding rocket flights, in coordination with balloon and aircraft flights from Wallops Island, Virginia, produced invaluable data on the electric fields associated with thunderstorms. This coordinated project illustrates the synergism possible within the elements of the suborbirtal program. Chemical release experiments will continue to be launched on sounding rockets in FY 1982 to measure winds, wind shears, temperatures, plasma motions, and electric fields in support of solar terrestrial studies. A new vehicle, the Black Brant X, has been successfully flown from Cape Perry, Canada, to facilitate studies of the polar cusp of the magnetosphere. This vehicle's extended performance provides a valuable new tool for the plasma physics program.

In the astronomy and high energy astrophysics disciplines, continuing emphasis is being placed on the development of instruments to be used for studies of stars and extended sources in the ultraviolet and X-ray spectral regions. Of special interest in FY 1981 was the development of an imaging gas scintillation proportional counter for X-ray astronomy. This insturment was flown successfully and produced good scientific results. The instrument is an excellent future candidate for the deployable special payloads concept described below, or for flight on the Advanced X-ray Astrophysics Facility, a major observatory mission under consideration for development later in the decade.

In FY 1982, emphasis will be placed on a concept called deployable special payloads (DSP). Under this concept, the capabilities of the Shuttle will be made available for sounding rocket experimenters, and will potentially increase scientific data acquisition periods from the present five minutes per flight up to 40 hours. The DSP concept calls for sounding rocket-type scientific instrumentation and support hardware to be carried aloft by the Shuttle as either attached or free-flying payloads, as appropriate, and then returned by the Shuttle. These payloads will have minimum interface with the Shuttle. Work on two such payloads will continue in FY 1982, one for high energy astrophysics and one for solar astronomy.

Fiscal year 1983 funds will provide for continuation of the efforts described above. Fiscal year 1983 funds will also support continued efforts on the deployable special payloads development activities.

Airborne Research

Research with instrumented jet aircraft has been an integral part of the overall NASA program in physics and astronomy since 1965. The aircraft platform provides a large payload capacity and facilities for extending observations over any region of the Earth and may be transported readily to high operational altitude near 13 kilometers (over 40,000 feet), in order to provide a cloud-free site for auroral geophysics experiments and astronomical observations. The possibility of conducting observations at this cloud-free altitude, above most of the infrared-absorbing water vapor of the Earth's atmosphere, has been essential in opening to astronomy the infrared region of the electromagnetic spectrum from one micrometer to one millimeter. The airborne platform also has the advantage of enabling scientists to participate directly in space research.

The airborne research program utilizes two aircraft, a C-141 instrumented with the 91 centimeter infrared telescope and a Lear jet instrumented for unique individual missions. The C-141A "Kuiper Airborne Observatory," which begain operational flights in 1974, is a full-scale, manned facility. The 91 centimeter f/13.5 infrared telescope operates through an open port, with a pressure bulkhead giving the astronomers a comfortable, shirt-sleeve environment in which to work. The telescope floats on a large air bearing that permits hours of accurate stabilization within a few arc seconds. The weight of this observatory is about 16 tons (14.5 metric tons).

In fiscal year 1981, 72 flights were flown to take advantage of the high altitude to make far-infrared observations, including, for the first time, an observation of the limb of the Sun at these wavelengths. We expect that the data will lead to a new understanding of the fine structure in the lower chromosphere. In fiscal year 1982, approximately 65 flights of the C-141 will be supported to continue exploration in the infrared of star forming regions, and to continue the development of more sensitive instrumentation for both photometry and spectroscopy.

In fiscal year 1983, airborne research funds will be used for the continuation of operation of the Kuiper Airborne Observatory to provide support for astronomical groups, and to continue the development of improved instrumentation for conducting infrared astronomy.

Balloon Program

For the development of scientific experiments for space flight and for independent scientific missions, it is desirable to test the instrumentation in the space radiation environment and to make observations at altitudes which are above most of the obscuring effects of the atmosphere, particularly for observations in infrared and cosmic ray astronomy. In many instances, it is necessary because of size and weight, as well as being less expensive, to fly these experiments on balloons. The funding for this program is utilized for balloons, helium, launch services, tracking and recovery, while funding for the experiments is provided from the supporting research and technology program.

During fiscal year 1981, twelve balloon flights were flown from four global sites to support the research activities of approximately six scientific organizations. One of these flights, launched from Australia, in conjunction with observations from the High Energy Astronomy Observatory, have established that the center of our galaxy is a variable gamma ray source. There is no satisfactory explanation for this variability within given theoretical models. Another noteworthy achievement by a recent series of balloon flights is the detection of what is believed to be radiation intrinsic to the remnant of the "Big Bang" explosion which may have started this universe.

In fiscal year 1982, about twenty balloon flights are planned which will continue scientific research in high energy astrophysics, solar astronomy, galactic astronomy, and space plasma physics. A scientific discipline which will receive added emphasis is that of gamma ray astronomy. Of particular interest is the area of nuclear line spectroscopy based on increased interest in nucleosynthesis of elements.

The fiscal year 1983 funding provides for continuation of the balloon program. In addition, discussions are taking place with the National Science Foundation for NASA to assume the management and operation of the Natonal Scientific Balloon Facility (NSBF), which is the nation's primary means for carrying out scientific balloon operations. The National Science Foundation, which currently funds the NSBF, has no plans for supporting this facility after fiscal year 1982; therefore, the fiscal year 1983 balloon program funding assumes responsibility for a larger share of the costs to operate this facility.

5. PLANETARY EXPLORATION, $177,600,000

FISCAL YEAR 1983 FUNDING LEVEL

Galileo development	$92,600,000
Venus orbiting imaging radar (VOIR) development	....
Mission operations and data analysis	38,500,000
Research and analysis	46,500,000
Total planetary exploration	177,600,000

The Planetary Exploration program includes the scientific exploration of the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are to understand the origin and evolution of the solar system, to better understand the Earth through comparative studies with the other planets, and to understand how the appearance of life in the solar system is related to the chemical history of the system. The projects undertaken in the past have been highly successful. The strategy that has been adopted calls for a balanced emphasis on the terrestrial-like inner planets, the giant gaseous outer planets, and the small bodies (comets and asteroids). Missions to these planetary bodies start at the level of reconnaissance and exploration to achieve the most fundamental characterization of the bodies, and proceed to a level of detailed study. The reconnaissance phase of inner planet exploration began in the 1960's and has now been completed, though we still know little about the nature of the Venus surface. Mars has provided program focus because of its potential as a site of biological activity. The Viking landings in 1976 carried the exploration of this planet forward to a new level of scientific and technological achievement, thereby setting the stage for the next step of detailed study. Analyses of the moon rock samples returned by Apollo continue to be highly productive as new insights into the early history of the inner solar system are achieved and as our theoretical concepts are revised accordingly. The continuing Pioneer Venus mission is carrying the study of our nearest neighbor, and closest planetary analogue, beyond the reconnaissance stage to the point where we have made a basic characterization of the massive cloud-covered atmosphere of Venus. This characterization has also provided some fundamental data about the formation of the planet.

The exploration of the giant outer planets began relatively recently with the Pioneer-10 and 11 flybys of Jupiter in 1973 and

1974. These simple reconnaissance spacecraft returned excellent data which contributed much to the later successes of the Voyager-1 and 2 spacecraft. Voyager-1 encountered Jupiter in March 1979 and Saturn in November 1980. Voyager-2 flew by Jupiter in July 1979, and then Saturn in August 1981. Our scientific knowledge of this part of the solar system has increased greatly in less than a decade. New data on the planets, satellites, and rings have revolutionized our concepts of the formation and evolution of the solar system. Now, the Pioneer-10 and 11 and Voyager-1 spacecraft are on escape trajectories from the solar system as they continue to monitor their uncharted environments. The Voyager-2 spacecraft is headed for an encounter with Uranus in 1986.

The Galileo mission is a cooperative effort between the United States and the Federal Republic of Germany. A wide range of science experiments, chosen to make maximum progress beyond the Voyager findings, has been selected. The Galileo development efforts are proceeding on schedule for a 1985 launch.

The pre-eminence of the United States program of planetary exploration has been based on technology leadership and on a foundation of strong, coordinated research and analysis programs. These programs ensure that full advantage is taken of the spacecraft data and samples acquired on completed and on-going missions, and that the necessary research is performed to maximize the return from ongoing and future missions. Included in the research and analysis efforts are data analysis, lunar sample and meteorite analysis, telescopic observations, theoretical and laboratory studies, and instrument definition. The highest scientific standards are maintained in these programs and both new and old concepts are subject to intense scrutiny. The programs also involve interdisciplinary coordination among various research groups. The results of the research are widely disseminated. The lunar sample analysis effort is mission-oriented and is coordinated with research by the National Science Foundation. A close coupling is maintained between the research programs and the planning activities that are undertaken to define the scientific rationale and technology needs for future missions.

A long term mission strategy for future low cost exploration of the solar system is in the process of formulation. Such a strategy will include missions to characterize the surface of Venus, to undertake initial missions to comets and asteroids, to further the exploration of Mars, and to continue the exploration of the outer planets and their moons. New approaches to spacecraft development and to mission operations are being examined.

GALILEO DEVELOPMENT

The Galileo mission, which will conduct direct and long-duration studies of Jupiter, is a vital link in providing the continuity, balance, and orderly progression of the exploration of the solar system.

The objective of this program is to conduct a comprehensive exploration of Jupiter, its atmosphere, magnetosphere and satellites, through a new deep space spacecraft concept which combines both remote sensing and direct measurements by an orbiter and an atmospheric probe.

The Galileo launch has recently been changed from a Shuttle/Centaur upper stage to a Shuttle/two-stage inertial upper stage. In order to provide sufficient energy to inject the Galileo spacecraft onto the trajectory to Jupiter, a small "kick" stage will be developed and integrated with the spacecraft to provide the final energy increment.

The Galileo mission will utilize a single Space Shuttle/inertial upper stage launch in 1985 of the orbiter and probe which will follow a Delta VEGA trajectory to Jupiter. The orbiter and probe will arrive on target in 1989 to conduct a twenty-month investigation of Jupiter, its satellites, and its magnetosphere. This mode of launch will allow six encounters with the satellites of Jupiter during the tour instead of eleven as originally planned. The probe will penetrate the atmosphere of Jupiter to conduct scientific investigations down to a depth where the pressure is equivalent to ten times the pressure exerted by the Earth's atmosphere, and the orbiter will relay information back to Earth.

In FY 1982, the orbiter and probe design, development, and fabrication activities are continuing and the fabrication of the major subsystems will be completed. Preparation for probe and orbiter system integration activities will take place during FY 1983.

The FY 1983 funding will provide for continuation of the orbiter, probe, and scientific instrument fabrication. The baseline Galileo spacecraft design will be retained with minimum modifications to accommodate the addition of a "kick" stage development which is required for an IUS launch of the Galileo mission. Funding will also be used for the procurement of long-lead parts for this propulsion system.

VENUS ORBITING IMAGING RADAR (VOIR) DEVELOPMENT

The Venus Orbiting Imaging Radar (VOIR) mission was planned as the first mission to map the surface of Venus globally to a resolution of better than one kilometer in order to characterize the current state of the planet and to determine its evolutionary history. The mission will not be initiated in FY 1982 as previously planned in accordance with the Administration's FY 1983 budget decision not to undertake development of this mission at this time.

MISSION OPERATIONS AND DATA ANALYSIS

Funds for the mission operations and data analysis program provide for the operations phase of planetary missions after development, launch, and initial in-flight checkout are completed. It also provides for multimission flight support. Currently active planetary missions being supported within mission operations and data analysis are Voyager-1 and 2, Pioneer-Venus, and Pioneer 6–11.

The objective of the Voyager mission has been to conduct comparative studies of the Jupiter and Saturn planetary systems and to perform studies of the interplanetary medium between the Earth and Saturn. Since their launches in 1977, the two Voyager spacecraft have encountered both the Jupiter and Saturn systems and achieved all of their original objectives. Many remarkable discoveries were made at these giant outer planets and much valuable scientific data (including 64,000 images) has been obtained. Voyager-1 is now on a cruise trajectory which will take it out of the solar system at a steep angle to the plane of the ecliptic. The spacecraft will collect data on the space environment as it proceeds to the outer limit of our solar system. Voyager-2 successfully flew near Saturn in August 1981 and was placed on a trajectory which will take it to an encounter with the planet Uranus in January 1986. If this spacecraft continues to operate satisfactorily, Voyager-2 may be sent outward from Uranus to an encounter with Neptune in 1989. Both spacecraft have experienced minor equipment failures, but are operating satisfactorily because of their design redundancies. Voyager-2 has an impaired command receiver and an instrument scan platform with reduced capabilities; however, a rewarding encounter at Uranus in 1986 is expected.

The objective of the Pioneer-Venus mission was to obtain detailed information on the Venusian atmosphere, to investigate the planet's environment, and to learn why the planet, so Earth-like in many respects, has an atmosphere so different. The mission consisted of two spacecraft: an orbiter launched in May 1978 and a multiprobe launched in August 1978. The orbiter arrived at Venus on December 4, 1978, and the four probes and multiprobe bus entered the atmosphere on December 9, 1978. This mission has been an outstanding success.

The objective of Pioneers 6–9 was to explore interplanetary space at radial distances from the Sun varying from 0.75 to 1.1 astronomical units (the Earth's distance from the Sun is 1 astronomical unit). The objective of Pioneer-10 and 11 was to explore space beyond 1 astronomical unit, the Asteroid Belt, and the environment of Jupiter. Pioneers 6–9, which were launched in 1965, are still operational. However, data is acquired only when unusual solar activities or special alignment with other spacecraft occur. Pioneer-10, launched in 1972, reached Jupiter in December 1973, and the gravity of the massive planet provided the extra impetus to ultimately take the spacecraft out of the solar system. Pioneer-11, launched in 1973, passed Jupiter in December 1974, and the spacecraft trajectory was influenced by the planet's gravity field in such a way that it flew by Saturn in 1979. Both Pioneer-10 and 11 have returned excellent data and continue to operate successfully as they proceed to escape the solar system in opposite directions. These spacecraft are attempting to detect the outer boundary of the Sun's influence while continuing to measure the space environment in the outer region of the solar system. Pioneer-10 is now more than 25 astronomical units from the Sun, closing on the orbit of Neptune.

The Viking Lander 1, redesignated the Mutch Memorial Station in January 1981 by the NASA Administrator, continues to operate in an automatic mission mode. In this mode, it collects and stores selected data at reduced levels for transmission to Earth at periodic intervals upon command. It is expected to continue to do so for several more years.

Planetary flight support provides for mission control and other activities which support the tracking, telemetry, and command functions for all planetary spacecraft. These activities include the acquisition, operation, and maintenance of mission operations and general purpose scientific and engineering computing capabilities at the Jet Propulsion Laboratory.

The FY 1983 funding will provide for the continuation of Voyager-1 post-Saturn encounter mission operations and the Voyager-2 cruise to Uranus. Analysis and publication of the results of the Jupiter encounter will be continued in FY 1983.

The FY 1983 planetary flight support funds will provide mission control and computing support for the Voyager mission and will also support the operation of the Pioneer-Venus and Pioneer-10 and 11 spacecraft.

RESEARCH AND ANALYSIS

The research and analysis program contains five elements required to assure that data and samples returned from flight missions are fully exploited; undertaking complementary laboratory and theoretical efforts; defining science rationale and develop required technology to undertake future planetary missions; coordinating an International Halley's Comet Watch, providing co-investigator support to the European Space Agency's Giotto mission to Halley's Comet; and for a proportionate share and occupancy of the mid-level facility for visiting scientists at the Infrared Telescope facilities on Mauna Kea, Hawaii. This facility will be titled to the University of Hawaii.

Supporting Research and Technology—The supporting research and technology is made up of six areas of effort; (1) planetary astronomy; (2) planetary atmospheres; (3) planetary geochemistry and geophysics; (4) planetary geology; (5) planetary materials; and (6) instrument definition.

The planetary astronomy activity includes all planetary observations made by ground-based, airborne and Earth-orbital telescopes. Observations are made at a wide range of wavelengths from ultraviolet to radio. The rate of new discoveries continues to be high. The data acquired are used both for basic research in support of planetary program objectives and for direct support of specific flight missions.

The planetary atmospheres activity includes data analysis, and laboratory and theoretical efforts. The properties of other planetary atmospheres are amenable to measurement and can aid us in better understanding our own weather and climate. Observations of the atmospheres of Venus and of Jupiter, acquired by Pioneer-Venus and by Voyager, have laid the basic groundwork for major advances in our knowledge about atmospheric sciences.

The planetary geochemistry and geophysics activity is broad in scope and includes studies of the composition and structure of all classes of solar system objects and the synthesis of data from all sources that relate to the origin and evolution of the solar system. The program supports the synthesis of planetary data already obtained, and the assembly of information needed to prepare for future missions. Both Voyager and Pioneer Venus are providing key data for the research efforts undertaken in this program.

To date, the planetary geology activity has focused on studies of the inner planets (including the Moon). Voyager data pertaining to the moons of Jupiter and Saturn have provided a new dimension for this effort. The geology program is a broadly based effort in which comparative studies of common processes affecting all the inner planets provide a powerful technique for unravelling individual planetary histories, including their early states. Imaging data, from both spacecraft and from ground-based radar, provide the basis for much of the data analysis.

The planetary materials activities support an active scientific effort to determine directly the chemistry, mineral composition, age, physical properties, and other characteristics of returned lunar samples and of meteorites that fall to Earth. Recently, extraterrestrial dust grains have been collected for analysis. These studies continue to yield new and otherwise unobtainable information about the solar system, particularly about its early history. This program is coordinated with lunar sample research supported by the National Science Foundation.

The instrument definition activity is directed toward ensuring that the science return from future spacecraft missions is maximized by the availability of the state-of-the-art scientific instrumentation.

Advanced Programs—The objective of advanced programs is to provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. Prospective planetary missions are identified and defined through long-range studies; their technological and fiscal feasibility is evaluated, and their scientific merit is determined through interaction with the scientific community. For near-term missions, detailed project planning and technology readiness studies are carried out so that these missions may be undertaken on schedule and within fiscal constraints.

Mars Data Analysis—The Mars data analysis efforts continue to assure that we capitalize on the wealth of data provided by Viking. This activity covers a broad scope of the returned data related to the disciplines of biology, chemistry, geology, and meteorology. This effort will be discontinued in FY 1983.

Halley's Comet Co-Investigations and Watch—The International Halley's Comet Co-Investigations and Watch will capitalize on the opportunity to observe Comet Halley during its next apparition in 1985–1986 by supporting co-investigating scientists on the European Space Agency (ESA) Giotto mission and by conducting complementary remote sensing investigations using both Earth orbiting and ground-based facilities. ESA is planning its Giotto mission to fly by Halley in March 1986. Concurrently, an observation program called the International Halley Watch will be conducted to coordinate scientific observations of Comet Halley. The objectives of the Watch are: (1) to coordinate scientific observations of Comet Halley throughout its 1985–1986 apparition; (2) to promote the use of standardized instrumentation and observing techniques; (3) to help insure that data are properly documented and archived; and (4) to receive and distribute data to participating scientists.

During FY 1983, research efforts will continue in the areas of planetary astronomy, planetary atmospheres, planetary geochemistry and geophysics, planetary geology, planetary materials, and instrument definition. Telescopic observations will provide data complementary to that obtained from the flight missions with emphasis on the outermost planets, the comets and the asteroids. A variety of efforts will be pursued to improve our understanding of planetary atmospheres, including laboratory studies of reactions in deep atmospheres and in tenuous cometary atmospheres. In the geochemistry-geophysics area, research efforts will be carried out to better understand the present state of evolution of individual bodies and of the solar system in general. Geology research will be directed at specific problems in understanding the various processes that have shaped planetary surfaces, and will also include geological analyses and a cartography effort based on the Galilean satellite imaging data acquired by Voyager. Analysis of lunar samples, meteorites, and cosmic particles will continue in order to determine their chemical and physical properties and thereby to derive their origin and evolutionary history. Instrument definition for future missions will be continued in FY 1983.

In FY 1983, work will proceed on advanced mission definition, and on instrument definition and development in support of future planetary science mission opportunities.

The FY 1983 Halley's Comet Co-Investigations and Watch funding is required to support the United States co-investigators involved in the design of the European Space Agency's Giotto experiments for the Halley's Comet mission, and also to provide support for a Jet Propulsion Laboratory management team together with several scientists at other institutions who are establishing a worldwide network for a astronomical study of Comet Halley in 1986.

6. LIFE SCIENCES, $55,700,000

FISCAL YEAR 1983 FUNDING LEVEL

Life sciences flight experiments	$24,000,000
Research and analysis	31,700,000
Total life sciences	55,700,000

The goals of the Life Sciences program are to provide a sound scientific, medical, and technical basis for safe and effective manned space flight and to understand the basic mechanisms of biological processes using the unique capabilities of the space program. Results from the research program are applied to immediate needs in the maintenance and health of the astronauts; to the design of future support systems for the astronauts; to understanding the response of biological systems to weightlessness; to the design of controlled life support systems for use in future missions; and to the understanding of the larger scale system—the biosphere of the planet Earth.

In the longer term, this program is the key to developing a capability to sustain a permanent manned presence in space. The program includes both ground-based and space research which are mutually supportive and integrated. The program uses a composite of disciplines and techniques in both biology and medicine to address space-related medical problems and fundamental biological processes.

In research and analysis, the life sciences program includes several major elements. The operational medicine program is directly applicable to the immediate operational needs of the Space Shuttle.

The biomedical research program is focused on understanding and preventing any adverse physiological changes which occurs in space flight. Advanced life support is a program of research and technology development for life support systems necessary to maintain life in space autonomously for long periods of time. The space biology program consists of flight and ground-based experiments that focus on understanding the effects of zero gravity on plants and animals. The unique properties of space (e.g., microgravity) provide, for the first time, an opportunity to explore significant problems in biology under controlled conditions that cannot be duplicated in laboratories on Earth. Finally, the program in terrestrial biology deals with the origin and early evolution of life and the interaction of life with its environment. The insights gained from this study are important both from a cosmological view and in understanding what would comprise a closed ecological system that could support man in space.

The goals of the operational medicine and biomedical research programs are to assure astronauts and payload specialist health and ability to function effectively in space environment. Eventually, experienced gained from the medical operations support to space flight will allow a broader segment of the population to participate in all aspects of future space missions. Particular emphasis is placed on testing countermeasures designed to prevent untoward physiological responses associated with exposure to the space environment. It is essential that long-term monitoring of the space transportation system crew be performed in a standardized and organized fashion in order to develop risk factors and establish the long-term clinical significance associated with repeated exposure to the space environment. In addition, biomedical research is designed to understand the psysiological basis for problems encountered in manned space flight. Areas of emphasis include: space motion sickness, cardiovascular deconditioning, bone and muscle loss, and radiation damage. Results of this research have a near-term payoff to operational medicine in the form of countermeasures to be tested in flight. This research will also be utilized in the future development of flight experiments for the first dedicated life sciences Spacelab (Spacelab 4).

The advanced life support system program supports activities ranging from the development of less constraining and more efficient space suits for the astronauts, to scientific work in chemistry and biology necessary to understand how life maintains itself in systems which only receive energy from the external environment. All are aimed at future needs of manned space flight.

The objective of space biology is the further understanding of basic physiological mechanisms through the use of gravity and the space environment. Ground-based research and flight experiments have been integrated in the study of fundamental biological questions. Plant and animal experiments have flown on three Soviet Cosmos satellites and as a payload on a Shuttle orbital flight test; and experiments are under development for all Shuttle flights up through Spacelab–4. These experiments explore the physiological effects of space flight on inner ear function, blood factors, bone formation, and plant growth and structure. The information obtained will contribute to the solution of biological and medical problems on Earth as well as contribute to man's effective functioning in space.

One goal of terrestrial biology research is to understand the origin and distribution of life and life-related molecules on Earth and throughout the universe. Particular emphasis is placed on developing sound hypotheses which ultimately will lead to discovering the relationships which link the beginnings of life to the formation of the solar system and the Earth itself. Ground-based research on model systems and analysis of extraterrestrial materials, coupled with flight experiment results, are clarifying the mechanisms of, and environments conducive to, the formation of essential biomolecules. An immediate extension is to emphasize studies to understand the interaction of the biota with the Earth's environment on a global scale and thereby provide a more comprehensive picture of life—its past, present, and future. NASA's unique ability to monitor changes on a global scale, coupled with its expertise in the required life sciences disciplines, will allow progress toward this goal.

LIFE SCIENCES FLIGHT EXPERIMENTS

The objective of the life sciences flight experiments program is to assimilate information from the various life sciences disciplines and translate it into payloads designed to expand our understanding of the basic physiological mechanisms involved in adaptation to weightlessness. The program includes selection, definition, inflight execution, data analyses, and reporting of medical and biological investigations. Past experience indicates that man clearly undergoes physiological changes in weightlessness. Thus far these changes appear to be reversible upon return to Earth. However, many of the observed changes are physiologically significant and are not well understood. With weightless exposure beyond a few months, these changes may prove irreversible and acquire medical significance. Early Shuttle/Spacelab missions are suitable for gaining a greater understanding of the early physiological responses to weightlessness, which will improve the management of several existing problems (e.g., space motion sickness) and will enhance the confidence of estimating the physiological consequences of more sustained weightless exposure.

Current activities involve the development of life sciences flight experiments for early Shuttle flights (e.g., OSS–1, Spacelab–1, Spacelab–2, Spacelab–3, and Spacelab–4). Most of the experiments onboard early Shuttle flights serve as pathfinding activities for Spacelab–4, the first mission dedicated entirely to life sciences investigations. Hardware and experimental protocols for early flights through Spacelab–2 are well developed and are proceeding toward planned launch dates. Experiments on Spacelab–3 will involve evaluation of functional performance and biocompatibility of hardware that is essential to human and animal investigations to be conducted on Spacelab–4.

Twenty-five investigations have been tentatively selected as the scientific payload for Spacelab–4. These investigations have been combined into a comprehensive, integrated exploration of the known problems of manned space flight using both human and animal subjects. Teams of principal investigators will examine cardiovascular adaptation, space motion sickness. muscle wasting, demineralization of bone, and the early anemia of weightlessness. This mission is unique in several respects. It is the first mission ever dedicated entirely to life sciences. It involves highly skilled life scientists as payload specialists, permitting the use of numerous experimental techniques and procedures never before utilized in space, and the Spacelab-4 experiments employ complementary experimental designs in human and animal investigations in order to validate animal models for human physiology aloft.

FY 1983 funding is required for the continuing definition and development of investigations which will be flown on future Spacelab missions, particularly Spacelab-4. Final development of engineering and biocompatibility studies for Spacelab-3 will be completed in FY 1983. Tentative selection of investigations for the first dedicated life sciences mission (Spacelab-4) has been completed and, in FY 1983, the design of flight hardware will be finalized and fabrication will be initiated.

RESEARCH AND ANALYSIS

The research and analysis activity of the life sciences program is concerned with ground-based research in biological and biomedical problem areas that have been identified in previous manned flights. The program is comprised of five elements: (1) operational medicine; (2) biomedical research; (3) space biology; (4) terrestrial biology; and (5) life support systems research.

The life sciences operational medicine program is responsible for bringing the science, technology, and practice of medicine to bear on solving the problems of sustaining, supporting, and protecting individuals working in the space environment. This includes assuring physical welfare, performance, and adequate treatment of inflight illnesses or injuries. The space transportation system will allow for a complement of crews of both sexes and of varied background and age, who will work for different lengths of time in the unique environment of space. The new dimension of frequent and repetitive exposure to zero-gravity has been introduced. Such manifestations as "space motion sickness", fluid shifts, endocrine shifts, which can cause decreased performance in flight, decreased postflight cardiovascular tolerance and possible aggravation of latent diseases, will be carefully documented and either prevented or mitigated to the extent possible. To this end, specific operational requirements such as careful medical selection, periodic evaluation of health status (including pre- and post-flight medical observation), and in-flight monitoring of the time course of adaptation and performance in the space environment will be continually reevaluated and updated. Significant emphasis is placed on real-time testing, under controlled conditions, of promising countermeasures developed by the research and analysis program.

The objective of the biomedical research program is to develop the basic medical knowledge needed to enable men and women to operate more effectively in space. The program is organized into discrete elements, with each designed primarily to rectify a particular physiological problem known or expected to affect the human organism in prolonged or repetitive space flight. Thus, such problems as motion sickness, bone loss, and hormonal disturbances are under intense scrutiny not only to provide a better understanding of their underlying causes, but also to develop more effective preventative measures. The program makes extensive use of ground-based simulation techniques which evoke, in both humans and animals, physiological changes similar to those seen in space. In the course of this research, measuring techniques which provide greater insight into physiological processes are frequently developed.

The space biology activity explores the rôle of gravity in life processes and uses gravity as an environmental tool to investigate fundamental biological questions. Specific objectives are to: (1) investigate and identify the role of gravity in plant and animal cellular processes, embryonic development, morphology and physiology; (2) identify the mechanisms of gravity sensing and transmission of gravity perception information within both plants and animals; (3) identify the interactive effects of gravity and other stimuli (e.g., light) and stresses (e.g., vibration) on the development and metabolism of organisms; (4) use gravity to study the normal nature and properties of living organisms; and (5) extend the limits of knowledge about plant and animal growth and metabolism to provide for long-term survival and multigeneration reproduction of life in space. This program provides important ground-based information needed to develop future space flight experiments and life support systems.

Terrestrial biology includes the study of the origin, evolution, and distribution of life and life-related molecules on Earth and beyond. Sophisticated analyses of life as we know it—its chemical precursors, and its origin, coupled with extrapolation to extraterrestrial environments—afford a unique opportunity to address a most fundamental question regarding the origin of life on Earth and the existence of such processes elsewhere. The current research program also is uncovering an intimate association between the origin and evolution of life on Earth and the processes which shaped the evolution of the solar system itself. The influence of the physical and chemical properties of the primitive environment on the rate and direction of evolution of life is also shedding light on the interaction of the contemporary Earth's biota with the biosphere—the land, oceans and atmospheres. The reverse is also true. Remote sensing and data handling capabilities will be assessed for their ability to provide data, on a global scale, of how life modulates the cycling of elements and molecules through these components. These analyses will allow the development of models to test the stability of the ecosystem and predict its resiliency to perturbations, either natural or life-related, as well as provide insight into the origin and evolution of primative ecologies.

The life support systems research program concentrates on enhancing our ability to support long-duration manned presence in space and on optimizing the productivity of mixed spacecraft crews. Improvements are sought in spacecraft habitability and man-machine system engineering methods as well as a means to provide air, water, and food to support life directly. The program has developed technology for building apparatus to regenerate spacecraft air and water supplies in flight and is investigating the scientific basis for improved technology and for new system approaches that would include food recycling for very long missions. Research is in progress on space suits for quick reaction situations and on scientific approaches to designing space tools and work stations.

For each Shuttle flight, the operational medicine program will investigate and collect information on occupational exposures in zero-gravity, inflight clinical testing of countermeasures, especially in the areas of cardiovascular deconditioning and motion sickness, and development of health care procedures compatible with the space environment. Annual and pre- and post-flight medical data will be collected in order to better define responses of different population groups to spaceflight.

The biomedical research program will focus primarily on the motion sickness problem because of its relevance to Shuttle operations. Cardiovascular and musculoskeletal studies will also be pursued in recognition of the considerable fundamental knowledge that must be acquired in these areas before effective countermeasures to the effects of spaceflight can be devised. Increased awareness and understanding of the radiation hazard has resulted in more emphasis being placed on the biomedical effects of high energy radiation and upon radiation protection.

The space biology program will study the stress responses by hypo- and hyper-gravity and the relationship of these responses to those provoked by other stresses and stimuli. The use of gravity as a tool to investigate fundamental hormonal responses and basic biological control mechanisms will be expanded. The space biology program will provide ground-based data for definition of Shuttle/Spacelab flight experiments for OSS-1 and Spacelab 1 through 4.

Terrestrial biology research will concentrate on studies delineating the effect of the physical and chemical environment of the primitive Earth on both the rate and direction of evolution of life. Studies of both primitive and extant ecologies will be emphasized. Strategies will be developed for measurement of major biologically-mediated molecular cycles through the biosphere. This research forms the foundation, on a small scale, for a more complete understanding of present-day biotabiosphere interactions on a global scale.

The life support systems program will investigate basic biological processes and physical/chemical methods which will provide the capability to recycle waste, food, atmosphere and water. In addition, concepts for improved space suits for the Shuttle era will be brought to a state of development which will pave the way for implementation on future Shuttle missions.

In addition, the FY 1983 funding will support the reinstatement of a modest effort to support the definition and development of techniques to analyze extraterrestrial radio signals for patterns that may be generated by intelligent sources.

7. SPACE APPLICATIONS, $330,300,000

FISCAL YEAR 1983 FUNDING LEVEL

Resource observations	$132,200,000
Environmental observations	128,900,000
Applications systems	11,700,000
Technology transfer	4,000,000

Materials processing in space	28,600,000
Communications and information systems	24,900,000
Total space applications	330,300,000

The objective of the Space Applications program is to conduct research and development activities that demonstrate space-related technology, systems, and other capabilities which provide down-to-Earth practical benefits. These activities are grouped in the following general areas: resources observations, environmental observations, applications systems, technology transfer, materials processing in space, and communications and information systems.

In each of these areas, programs are being planned and conducted to contribute to the solution of pressing national, as well as international, problems and needs.

Resource Observations.—This program addresses the need for information of vital economic value to the United States and of worldwide humanitarian concern required for management of the world's limited food, water, and energy supplies, and the requirement for the identification of potential geological hazards. The principal objectives are to develop and demonstrate the use of space and space technology to provide the United States with a global capability for monitoring and forecasting major agricultural commodities, for water resources management, for land use assessment, for improving the exploration for mineral and energy resources, and for understanding the dynamic characteristics of the solid Earth and its crust, including tectonic plate motion, stability, and crustal deformation.

Environmental Observations.—Understanding the dynamics and limitations of our environment is essential to our long-term survival and to many of our day-to-day activities. Prediction of the weather, control of pollution, ship routing, storm warnings, and modeling of long-term trends in climate and in the stratosphere, are all areas where such understanding is put to day-to-day or strategic planning uses. NASA's environmental observations program aims at improving the understanding of processes in the atmosphere and the oceans, providing space observations of parameters involved in these processes and extending the national capabilities to predict environmental phenomena and their interaction with human activities. Because many of these phenomena are global or regional in extent, they can be most effectively, and sometimes solely, studied from space. NASA's program includes research efforts plus the development of new technology for global and synoptic measurements. NASA's research satellites give a special view of the radiative, chemical, and dynamic processes occurring in the atmosphere and oceans.

Applications Systems.—This program supports space applications requirements for use of airborne facilities and provides flight support to major segments of the space applications programs as well as to other NASA programs.

Technology Transfer.—The objectives of the technology transfer program have been to understand the information needs of potential users of remote sensing technology in the public and private sectors and to provide for the transfer of applicable technology to meet those needs.

Materials Processing in Space.—The materials processing in space program emphasizes the basic and applied science and technolgy of processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. The goal is to develop, test, and demonstrate the capabilities of spaceborne facilities for materials processing in the space environment, and to provide opportunities for independently funded users to exploit space flight for processing activities related to their own needs. In accordance with guidelines formulated and published in 1979, negotiations on several joint endeavors with private companies will continue in 1982. These activities are intended to encourage early tranfer of space activity in materials science to private sponsorship. Ground-based research in fiscal year 1982 will accommodate new areas of interest in materials science and in physical and chemical sciences as well as advanced technology development to meet needs identified in the research program. Development of the program's first space transportation system payload will be completed in 1983, leading to flight in early 1984.

Communications and Information Systems.—NASA efforts in communications in fiscal year 1982 and fiscal year 1983 will focus on completion of generic proof of concept communications technology, technical support to the United States government for the World Administrative Radio Conference/Regional Administrative Radio Conference planning efforts, and continued experiment support to the ATS 1-3-5 satellites. Information systems support will continue to emphasize development and demonstration of advanced data capabilities.

RESOURCE OBSERVATIONS

FISCAL YEAR 1983 FUNDING LEVEL

Landsat-D	$61,700,000
Extended mission operations	1,800,000
Magnetic field satellite	....
Shuttle/Spacelab payloads	2,800,000
Geodynamics	26,200,000
AgRISTARS	15,000,000
Applied research and data analysis	24,700,000
Total resource observations	132,200,000

The broad objectives of the resource observation program are to develop and apply space observation techniques to meet national and global needs for improved management of food, fiber, water, and land resources; improve our ability to systematically evaluate the composition and geometry of the Earth's crust in order to increase the effectiveness of global assessment, exploration, and development of mineral and energy resources; and increase our understanding of the solid Earth, its interior structure and composition, its rotational dynamics, the processes related to the movement and deformation of its crust, and the mechanisms associated with the occurrence of earthquake.

Principal elements of the programs include the development of space and supporting ground systems and improved data processing and analysis techniques; Shuttle and aircraft support for sensor and technique development; as well as basic and applied research for identifying, monitoring, analyzing, and modeling the vegetated and geological features of the Earth.

Both Landsat-2 and -3 are currently operating and providing data, although at reduced operational levels. Both Landsat-2 onboard video tape recorders are, however, inoperative, limiting its data return mode to real time operations. Landsat-3 has one fully operational tape recorder (capable of recording both Multispectural Scanner and Return Beam Vidicon data); the second recorder has failed. The overall tape recorder status for full worldwide coverage is such that a backup plan has been implemented by installation of ground recording equipment in selected foreign stations to assure worldwide coverage for key agricultural programs. There are now ten ground receiving stations operating in nine other countries.

Landsat-D development is proceeding with the launch of Landsat-D planned for 1982. Landsat-D will incorporate both the Thematic Mapper (TM) and Multispectural Scanner (MSS). Landsat-D, the backup spacecraft, will be available for launch 12-15 months later. In addition to continuing the availability of MSS data, Landsat-D will provide imagery with the improved spectral and spatial resolution of the thematic mapper needed to expand the use of space data for agricultural, water resources, land use, and other applications.

Another aspect of the resource observation program is the research associated with understanding the physical relationship of various types of vegetation and other surface features with the radiation which they emit or reflect; the development of models appropriate to the management of resources; and the evaluation of the use of space-derived data along with other data sources in meeting user needs. The scope of these activities ranges from individual scientific studies to projects such as the Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS).

AgRISTARS, a reseach, development and test program, addresses identified U.S. Department of Agriculture information requirements by combining NASA's unique remote sensing development expertise with complementary resources from Department of Agriculture and Department of Commerce. This program has become the focal point of remote sensing research for application to global vegetation assessments, both within the involved federal agencies and by the scientific community in general. Substantial progress has been made in developing techniques for enhancing the separability of crops, particularly small grains, corn and soybeans at or near harvest. Additional research is being conducted to develop procedures for improved separability during the growing season.

Studies of the movement and deformation of the Earth's crust, the rotational dynamics of the Earth, and the Earth's gravity and magnetic fields provide information needed to understand the processes leading to the release of crustal strain in the form of earthquakes; to improve our understanding of the formation of mineral deposits; to contribute to long-term weather and climate forecasting; and to better understand the Earth as a planet. Space techniques (laser ranging to satellites and the Moon, very long baseline interferometry using radio stars or satellites, and satellite mapping) are the only methods which can provide the precise measurements needed for these studies. In FY 1981 and 1982, measurements of the relative motion of several of the tectonic plates which form the Earth's crust, and of regional crustal deformation in California were conducted. Variations in the Earth's polar motion were monitored and correlated with changes in the angular momentum of the Earth's atmosphere resulting from shifts in atmospheric winds.

The Landsat-D thematic mapper (TM) and multispectral scanner (MSS) instruments have been delivered by the contractor, Hughes Aircraft Company, and are currently in the test phase following spacecraft integration at the mission contractor, General Electric. During FY 1982, the Landsat-D subsystems will be delivered.

The Landsat-D ground segment development has made significant progress during the past year. All data processing hardware elements required for the Landsat-D launch have been delivered and integrated with the facilities needed to operate the spacecraft, process the MSS data, and control the entire ground complex. Software development is nearing completion; facility acceptance tests are scheduled for 1982 and will be followed by an operational readiness test. The TM processing system design is nearing completion.

The focus of the Multispectral Linear Array (MLA) advanced technology development is on the development of technology for a future high performance MLA instrument for use as a diagnostic tool for fundamental research in remote sensing. The MLA solid state sensor has a number of significant advantages over existing mechanically-scanned sensors including electronic scan, inherent geometric and spectral registration and programmable high spatial and spectral resolution. The critical technology development and support research initiated in FY 1981 on the linear array instrument and the Shuttle Imaging Spectrometer will continue in FY 1982.

The objective of the Shuttle/Spacelab Payload Development project is to develop, test, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for resource observations research. The instruments which were flown on the second Shuttle orbital test flight in November 1981, the Shuttle Imaging Radar, for evaluation of the utility of spaceborne imaging radar for geologic exploration, and the Shuttle Multispectral Infrared Radiometer, which is used to determine the optimum spectral bands for surface materials classification, operated successfully. In FY 1982, these instruments will undergo post flight calibration and evaluation, and the data from the flight will be processed and analyzed. The Large Format Camera, required for high resolution mapping applications, will be removed from storage and prepared for flight on the Shuttle.

Remotely-sensed multispectral and high resolution panchromatic imagery of the Earth's surface will contine to be supplied by Landsat-2 and -3 to research and development and operational users for application to agriculture, forestry, range, water and land resource management; for geological studies; and for mapping. The on-orbit check-out of Landsat-D, planned to be launched in 1982 will be completed. Operation of the spacecraft, the multispectral scanner (MSS), and the MSS ground system will be turned over to the National Oceanic and Atmospheric Administration (NOAA) following checkout and verification of the performance of the space and ground segments. Landsat-2 and -3 will provide MSS overlap/backup to Landsat-D until mid-FY 1983. Both Landsat-2 and -3 will then be placed in a "standby storage" mode allowing rapid reactivation if needed.

The Landsat-D spacecraft and payload will be integrated and environmental tests performed in preparation for standby launch readiness in the event of a Landsat-D failure. Development of the thematic mapper (TM) ground system hardware and software will be completed in FY 1983 with an initial data production capability of 12 scenes/day by July 1983. Landsat-D TM multispectral data with improved spatial resolution, additional spectral bands extending into the middle and thermal infrared range, and improved radiometric sensitivity will then be provided to research and development users.

Critical technology development will be continued for a multispectral linear array (MLA) solid state sensor to meet evolving research requirements of the late 1980's for improved spatial and spectral resolution, improved radiometric sensitivity, and in-flight programmability. The emphasis in FY 1983 will be on the development and evaluation of the detector modules for the short wave infrared bands in order to develop the technology ultimately required for a series of on-orbit scientific experiments. Development of the short wave infrared focal plane, visible wavelength charge coupled device modules, and an optical subsystem will continue. In addition, long-range technology developments, directed toward an evolving capability to support a broader-based fundamental research program in land remote sensing experiments will be continued. Experiments will be conducted in the laboratory and aboard the Space Shuttle to test the advanced technology and apply it to basic research objectives.

The large format camera, completed in 1981, will be removed from storage and calibrated in preparation for flight on the first available Shuttle. The attitude reference system, which will provide precise pointing accuracy information, will be developed and flown in conjunction with the large format camera. A digital data system for the Shuttle imaging radar-A (SIR-A) will be developed and the SIR-A antenna modified to incorporate a fold mechanism for more efficient utilization of the available volume in the Shuttle payload bay. A tilt mechanism will be added for variation in antenna angle during data acquisition.

AgRISTARS activities conducted in conjunction with Department of agriculture (USDA), NOAA, Department of the Interior, and the agency for International Development to meet the information needs established by the USDA—early warning/crop condition assessment, foreign commodity production forecasting, supporting research, soil moisture, domestic crops and land cover, and conservation—will be continued. In FY 1983 research will continue on automated procedures for crop classification which significantly reduce analyst involvement while maintaining accuracy. Techniques will be developed for classifying large geographic areas, soil mapping, domestic land use and crop statistics improvements. Conservation practice identification activites will also be continued. This research will utilize simulated thematic mapper data from aircraft and spacecraft, when available, to assess improvements over MSS-based procedures.

In the applied research and data analysis program, the emphasis in FY 1983 will be on the development of techniques for information extraction from remotely-sensed data in the visible, shortwave, and thermal infrared regions, and from active and passive microwave sensors. In renewable resources, simulated aircraft TM data and TM spacecraft data, when available, over urban, rural, and degraded land areas will be analyzed to quantify the improvement in classification accuracy of TM data over MSS data. Synthetic aperture radar imagery from aircraft, Seasat, and SIR-A will be analyzed to determine its unique and complementary information content. Fundamental research activities in scene radiation and pattern recognition will be conducted and research topics in electromagnetic measurements and data handling and in infomation utilization and evaluation will be identified for future implementation. The joint program with the Japanese on snow and evapotranspiration monitoring will be completed.

In nonrenewable resources, laboratory and field experiments will be conducted to evaluate the utility of narrow band multispectral imagery and combinations of imagery from divergent regions of the spectrum (visible/infrared/microwave) for geological mapping. In FY 1983, special emphasis will be placed on the data collected by SIR-A and the shuttle multispectral infrared radiometer flown on the second Shuttle orbital test flight. Analysis of Magsat vector data will continue with emphasis on the crustal magnetism of higher latitude regions (e.g., the Arctic Basin and Greenland) where aircraft and ground-based measurements are hampered by external magnetic field effects. The airborne multiband thermal infrared scanner will be calibrated and tested in aircraft flights. Passive microwave sensors and scatterometers will be upgraded for field and aircraft use.

In FY 1983 seven new technique tests—cooperative projects between NASA and a user to develop and test remote sensing technology—will be initiated, emphasizing use of simulated aircraft TM data and spacecraft TM data, when available to delineate hydrologic features, model wetlands productive capacity; and aid in facility site selection for waste disposal, transmission line corridor siting, crop mensuration, crop condition assessment, and timber inventory.

The geodynamics program is conducted jointly with NOAA, United States Geological Survey, National Science Foundation, and Defense Mapping Agency through an interagency agreement. During the past several years, measurements (baselines) have been made at regional, continental and intercontinental scales using laser ranging to satellites and to the moon, and very long baseline microwave interferometric techniques have been used to study the rotational dynamics of the Earth and to model the Earth's gravity and magnetic fields. In FY 1983, the focus will be on continuation of studies of the western United States regional deformation and the relative motion of the North American and Pacific plates. Plans will be continued for a future joint United States/Japan Pacific plate motion study. The training of NOAA personnel for operation of mobile very long baseline interferometry systems will be completed, and operations phaseover to NOAA will be initiated. A consortium of European countries and United States scientists will initiate a program of measurement of crustal deformation in Europe and the eastern Mediterranean using the techniques pioneered by NASA. Theoretical modeling studies of crustal motion and internal core dynamics, and modeling of geopotential fields will be continued. Development of a geodetic receiver, which uses signals from the global positioning system to measure crustal strain accurately within a few hundred kilometers of a fault, and laboratory development of a three-axis cryogenic gravity gradiometer sensor for Earth gravity field surveys from space will be completed.

Earth Resources Technology Satellite (Landsat-D)

The objective of the Landsat-D project is to develop, launch, and operate an advanced land observing system and to assess and demonstrate the utility of satellite-based Earth resources remote sensing systems with the new experimental thematic mapper (TM) and the flight proven multispectral scanner (MSS). The Landsat-D launch is planned for 1982. The backup spacecraft will be available for launch 12-15 months after the initial launch. The major technical focus of the Landsat-D project involves a test of both the thematic mapper instrument's capabilities and an improved ground data handling system. The thematic mapper will offer higher resolving power and greater spectral coverage than existing instruments. These advantages promise to open up a significant number of new uses of Landsat data and to enhance many current uses.

The thematic mapper was delivered on schedule in October 1981 and has been integrated with the spacecraft. Its performance has exceeded specification requirements in many areas, and no significant integration problems have been encountered. The MSS was delivered in July 1981 and has also been satisfactorily integrated with the spacecraft.

All other elements needed to complete the assembly of the Landsat-D spacecraft have been delivered and integrated. These include the multimission modular spacecraft, the wideband communication system, and the global positioning system. The totally integrated spacecraft is in the systems compatibility and environmental test cycle. Activities are on schedule for a launch from the Western Space and Missile Center.

During FY 1982, the Landsat-D thematic mapper will be integrated and delivered. All other subsystems required for Landsat-D have already been delivered, or will be delivered during FY 1982 for integration with the spacecraft.

The ground segment hardware and software development has made significant progress during the past year. All data processing hardware elements required for the Landsat-D launch have been delivered and integrated with the facilities needed to operate the spacecraft, process the MSS data, and control the entire ground complex, Software development is nearing completion. Facility acceptance tests are scheduled for 1982 and will be followed by a three-month operational readiness test.

The TM processing system design is nearing completion. At the time of the Landsat-D launch, the TM research and development data production rate will be approximately one scene per day. During the first year of operation, the sensor performance will be characterized and the necessary software will be developed to permit a production rate of 12 scenes/day by mid-1983.

FY 1983 funds will be utilized to integrate and perform the acceptance testing of the Landsat-D spacecraft, and to continue the development of the TM processing system.

FY 1983 funds will also be utilized to operate the facilities for MSS operations for about six months after the launch of Landsat-D. After that time NOAA will fund and operate the facilities necessary for spacecraft control, mission management, and MSS data processing. The funds required for training NOAA personnel to accomplish these tasks are included in this budget estimate. Using data from the on-orbit performance of the TM instrument, the ground processing system will be upgraded to process 50 scenes per day by 1985. Current planning assumes the TM processing system will be turned over to NOAA at that time.

Extended Mission Operations

The objective of extended mission operations is to capitalize on the continued performance of Earth resource observation satellites (including Landsats) beyond the initially planned mission duration. Data products from these missions are being used to support research and operational activities in agriculture, water resources, geology, and land use. In the case of Landsat, some operational requirements of Federal and State agencies, plus many private interests are now being satisfied.

Both Landsat-2 and -3 are currently operating and providing data, although at reduced operational levels. Both Landsat-2 onboard video tape recorders are, however, inoperative limiting its data return mode to real-time operations. Landsat-3 has one fully operational tape recorder (capable of both multispectral scanner and return beam vidicon data). The second Landsat-3 recorder has failed, however, a backup plan has been implemented by installation of ground recording equipment in selected foreign stations to assure worldwide coverage for key agricultural programs. There are now 10 ground receiving stations operating in 9 other countries.

Resolution of Magsat data was completed in FY 1982. Preliminary maps of crustal magnetic anomalies have been prepared and distributed to a group of scientific investigators. A global magnetic map based on Magsat data was accepted as the worldwide standard by the International Association of Geomagnetism and Aeronomy.

The FY 1983 funding will support the continued acquisition of remotely-sensed multispectral and high resolution panchromatic imagery of the Earth's surface from Landsat-2 and -3 for both research and development and operational users. Landsat data will be applied to agricultural, forestry, and water and land management studies. Landsat-2 and -3 are planned to be retired from service in March 1983, subject to the satisfactory launch and operation of Landsat-D. Magsat data will be concluded in FY 1983, and a final set of magnetic field models and crustal anomaly maps will be issued.

Shuttle/Spacelab Payload Development

The objective of this project is to develop, test, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for resource observations research. Instruments were completed and successfully flown on the second Shuttle orbital test flight. Development of the large format camera is complete.

The instruments flown on the second Shuttle orbital test flight were the Shuttle imaging radar which is required for evaluation of the utility of spaceborne imaging radar for geologic exploration, and the Shuttle multispectral infrared radiometer, used to determine the optimum spectral bands for surface materials classification; and the Ocean Color Experiment, which can differentiate ocean colors and identify algae concentrations for fishery applications. In FY 1982, these instruments will undergo postflight calibration and evaluation, and the data from the flight will be processed and analyzed. The large format camera will be maintained in storage, pending preparations for flight on the Shuttle. Interface compatibility studies and integration support will be initiated, and electrical and mechanical spares will be procured. System design trade-off studies will be initiated for an advanced Shuttle radar system.

During FY 1983, development of the attitude reference system will be completed, and will be delivered and integrated with the large format camera. The camera package will be shipped to the Kennedy Space Center for integration as part of a Shuttle cargo and flown on a future Shuttle mission. Feasibility and preliminary design studies will be conducted on a fold and tilt radar antenna to provide more efficient utilization of the Shuttle payload bay volume as well as selectable look angles. System design studies will be conducted for an improved imaging radar evolving from the Shuttle Imaging Radar flown on the second Shuttle orbital test flight.

Geodynamics

The geodynamics program makes use of the unique capabilities provided by space techniques to improve out understanding of the dynamic processes occurring within the Earth and at its surface. The objectives of the program are to contribute to studies of earthquake mechanisms by measuring and modeling crustal deformation at active plate boundaries; to verify and extend tectonophysical theories by measuring the contemporary motions of the plates and determining the plate-driving forces; to study causative relationships between variations in the Earth's polar motion and rotational rate with earthquake occurrences, internal core dynamics, and other physical phenomena; to map and model the global gravity fields for studies of crustal processes associated with the formation of mineral and petroleum deposits; to study mantle connection and the internal composition and structure of the Earth; and to facilitate the establishment of new geodynamic measurement services which will make use of precise position determination methods.

The principal activity under the geodynamics program is the crustal dynamics project. This project supports the development of laser ranging and very long baseline interferometry systems for measurement of plate motion, plate stability, regional crustal deformation, polar motion, and Earth rotation, and is expected to contribute to the understanding of why and how earthquakes occur, and perhaps, to the development of earthquake prediction methods. Project activity is conducted jointly with the National Oceanic and Atmospheric Administration, the United States Geological Survey, the Natonal Science Foundation, and the Defense Mapping Agency, through an interagency agreement for the application of space technology to crustal dynamics and earthquake research. The laser network suppots the project through the acquisition and processing of laser data for sites in the United States the Pacific, South America, and Australia.

Beginning in 1981, epoch measurements (baselines) were obtained for studies of crustal deformation over a large portion of California and in other parts of the western United States. In 1982, and subsequent years, these measurements will be repeated to obtain deformation rates. A highly mobile laser system was placed in operation in 1981, and work was continued on the development of mobile very long baseline interferometry systems and laser systems. In response to an announcement of opportunity issued in 1980, 60 domestic and foreign investigators were selected to analyze data acquired by the crustal dynamics project.

Development has continued on a geodetic receiver design (SERIES), which uses signals from the Global Positioning System. SERIES will provide rapid (few days) and accurate (± 1 cm) measurement of crustal movement within a few hundred kilometers of a fault. Also in 1981, an interagency plan was approved for initiation of a national crustal motion network by NOAA using NASA equipment, for completion and operation of a polar motion monitoring network (POLARIS) by NOAA, and for establishment of local crustal strain monitoring networks by U.S. Geological Survey using the Global Positioning System receivers. The feasibility of using satellite-to-satellite tracking to substantially improve gravity field surveys was demonstrated in the laboratory, and initial models of the vector components of the Earth's magnetic field were produced.

In FY 1983, the western United States regional deformation measurements and measurements of the relative motion of the North American and Pacific plates will be continued. Analysis of these data and earlier data will provide the first maps of large-scale crustal deformation in the western Unied States. Planning will be continued ffor a joint United States/Japan Pacific plate motion study. The training of NOAA personnel for operation of mobile very long baseline interferometry systems and phaseover to NOAA operation will be completed. Operation of the laser network will be continued at the reduced level. Theoretical modeling studies of crustal motion and internal core dynamics, and modeling of geopotential fields will be continued. Development and field tests of the SERIES unit and laboratory development of a three-axis cryogenic gravity gradiometer sensor will be completed.

AgRISTARS

AgRISTARS, a research, development and test program, addresses identified Department of Agriculture (USDA) information requirements by combining NASA's unique remote sensing research and development expertise with complementary resources from the USDA and Department of Commerce. Improved information on world agricultural potential production has been identified by USDA as a major need for establishing effective United States and international food and agriculture policies, and for efficient operation of United States agricultural markets. With present resource limitations and political situations in many countries, aerospace remote sensing provides the only feasible means for making significant improvements.

This program has become the focal point of remote sensing research for application to global vegetation assessments, both within the involved federal agencies and by the scientific community in general. There is no other existing research and development program that would enable this country to obtain the potential for global vegetation assessments.

The major NASA thrust in AgRISTARS is to conduct the research, development, and test activities necessary to identify and validate basic techniques for extracting useful information from remotely-sensed data for the purpose of inventorying vegetation types and assessing their condition. Substantial progress has been made in developing techniques for enhancing the separability of crops, particularly small grains, corn, and soybeans at or near harvest. Additional research, however, is required to develop procedures that are valid early in the growing season. Present results obtained with simulated thematic mapper data hold promise for much improved separability of corn/soybeans at earlier growth stages, and for accommodating a wider range of agricultural conditions, e.g., small fields. Major questions regarding the ability to remotely measure soil moisture have been positively answered, but the conversion of these measurements to meet information needs remains to be developed.

Major FY 1983 milestones for the technique development project include completion of a multiple crop technique development and test activity. This activity includes separation of corn and soybeans and small grains.

Major FY 1983 milestones for supporting research include research on classification techniques which emphasize use of spatial information and improved understanding of physical processes that influence the energy emitted or reflected from scene elements for improving spectral classification procedures. Research on the use of spectral data for crop condition assessment will focus on development of crop growth and yield models which accept remotely-sensed data.

Three problems encountered during the first two years of the program will be addressed in FY 1983. These include separating small grains by utilizing multispectral scanner data, developing spectral inputs to yield and crop condition models, and developing applications of statistical sampling theory for remotely-sensed data.

Emphasis will be given to development of techniques for evaluating thematic mapper data in such applications as crop identification and area measurement, identification of conservation practices, soil practices, soil mapping, and forest species identification.

Research in the use of microwave techniques for improved crop identification and soil/snow moisture monitoring will be continued.

Applied Research and Data Analysis

The goal of the applied research and data analysis activities is to develop thorough remote sensing capabilities that aid in the management of renewable and nonrenewable resources and to monitor the impact of man on the natural environment, and to perform the advanced technology development and detailed system definition studies required prior to initiation of new space flight hardware development. This program incorporates the ground-based and aircraft-based activities for renewable and nonrenewable resource observations, research; system definition studies of flight hardware sensors and missions in renewable and nonrenewable resources and in geodynamics; advanced technology development required to implement new sensors and Shuttle experiments; and feasibility and conceptual design studies of future sensors and Shuttle experiments.

The overall objectives of this effort are to improve machine-aided interpretation (classification and data handling techniques which are needed to increase efficiency in extracting useful information from space-derived data for the research community), to test this capability with researchers through technique tests; to analyze science requirements for new types of space-acquired data, to develop and test ground-based or airborne systems that are derived from space technology, to perform feasibility, conceptual design, and detailed systems definition studies of new sensors and missions, and to perform the advanced technology development necessary to implement these new sensors and missions.

In renewable resources, the focus is on extending and strengthening our fundamental understanding of the remote sensing process, evaluating improvements to land cover inventory and monitoring resulting from use of the thematic mapper, the thermal infrared portion of the spectrum, and passive and active microwave data; devleloping improved ground and aircraft microwave sensors and data processors; conducting tests which determine the applicability and limitations of these techniques; and performing feasibility and conceptual design studies of future sensors and missions to ensure the conceptualization of high priority future capabilities in remote sensing of Earth resources. Techniques for combining Seasat synthetic aperture radar and Landsat multispectral scanner data have been developed and were tested in 1981. Simulated thematic mapper data was compared with multispectral scanner data, and an improvement of 20 percent in classification accuracy due to improved spatial resolution of a forest site was demonstrated. In fiscal year 1982 the potential improvements in classification accuracy as a result of enhanced thematic mapper spectral resolution and extended spectral range will be explored.

The objectives of the nonrenewable resources effort are to develop techniques for extracting useful geological information from remote sensing measurements; to employ remote sensing techniques in unique and innovative ways for studies of crustal geology; to develop improved geological models which make effective use of unique types of information that can be derived from space-acquired data; and to evaluate experimentally the utility of remote sensing methods for specific geological applications. The NASA-Geosat Test Case Project, a joint research venture with private industry to assess the utility of remote sensing methods for geological mapping, was successfully completed in 1981. In fiscal year 1982 greater emphasis will be placed on the use of thermal infrared and microwave remote sensing techniques. Development of an infrared aircraft scanner will be completed and the scanner flown during 1982 to collect six-channel multispectral data in the 8-13 micron spectral region over a series of western United States test sites. In addition, intensive analysis and interpretation of the radar imaging data obtained during the second Shuttle orbital test flight is planned in fiscal year 1982.

In technique tests (TT's), remote sensing techniques, are developed and tested jointly with potential users in their resource management environment. Four multispectral scanner-based TT's involving the assessment of irrigated lands for water management, monitoring insect defoliation of hardwood forests, classifying crops using soil data, and digital mapping of irrigated cropland in western acquifiers will be completed in fiscal year 1982. Also during fiscal year 1982, planning will be initiated on seven tests designed to provide a definitive test of the thematic mapper information extraction techniques. These include hydrologic feature delineation, wetlands productive capacity modeling, facility site selection for waste disposal, transmission line corridor siting, crop mensuration, crop condition assessment, and timber inventory.

The focus of the multispectral linear array (MLA) advanced technology development (ATD) is on the development of the technology for a future high performance MLA instrument for use as a diagnostic tool for fundamental research in remote sensing. The MLA solid state sensor has a number of significant advantages over existing mechanically-scanned sensors including electronic scan, inherent geometric and spectral registration, and programmable high spatial and spectral resolution. The critical technology development and supporting research initiated in FY 1981 on the linear array instrument and the Shuttle imaging spectrometer is being continued in FY 1982.

In renewable resources, the FY 1983 funding will support continuation of research in land resources remote sensing technique development, fundamental remote sensing investigations, processing technique development, and sensor and mission studies.

Planned nonrenewable resources research will extend into other portions of the electromagnetic spectrum concentrating on the thermal infrared and microwave regions. Measurement capabilities from aircraft platforms will be expanded and upgraded with the development of digital data recording systems for airborne radars; the six-channel multiband thermal infrared scanner will be tested from an aircraft platform. Experimental remote sensing data collected during the second orbital test flight of the Space Shuttle (i.e., shortwave infrared and radar measurements) will be analyzed in detail. The Magsat principal investigators program will be completed in FY 1982, and a set of global magnetic field maps derived from these data will be published in FY 1983.

In FY 1983 seven new thematic mapper simulated-based technique tests will be initiated dealing with delineation of hydrologic features, modeling of wetlands productive capacity, site selection of facilities for waste disposal, siting of transmission line corridors, assessing crop conditions, and timber inventorying.

The multispectral linear array advanced technology development efforts initiated in FY 1982 will be continued in FY 1983. The visible charge-coupled device and infrared Schottky barrier array work will be completed. The shortwave infrared detector development will continue with initial modules delivered for evaluation in late 1983. In-house test and evaluation capabilities will be upgraded at the Goddard Space Flight Center and the Jet Propulsion Laboratory to evaluate the modules. Follow-on Shuttle interface studies will be conducted to define a potential experimental multispectral linear array Shuttle mission. Technology development of the Shuttle imaging spectrometer will continue with additional optical design, onboard data processing, and focal plane development. The supporting aircraft instrument program will be continued in FY 1983 to provide high resolution spectral and spatial data for fundamental remote sensing research, and to optimize the design of the Shuttle Imaging Spectrometer.

ENVIRONMENTAL OBSERVATIONS

FISCAL YEAR 1983 FUNDING LEVEL

Upper atmospheric research program	$16,500,000
Applied research and data analysis	54,700,000
Shuttle/Spacelab payload development	3,700,000
Operational satellite improvement program	6,000,000
Earth radiation budget experiment	24,000,000
Extended mission operations	10,000,000
Upper atmospheric research satellite experiments and mission definition	14,000,000
Halogen occulation experiment	....
National oceanic satellite system (NOSS)	....
Total environmental observations	128,900,000

NASA's environmental observations program has the goals of improving the understanding of processes in the atmosphere and the oceans, providing space observations of parameters involved in these processes and extending the national capabilities to predict environmental phenomena and their interaction with human activities. Because many of these phenomena are global or regional, they can be most effectively, and sometimes solely, studied from space. NASA's program includes scientific research efforts plus the development of new technology for global and synoptic measurements. NASA's research satellites provide a unique view of the radiative, chemical, and dynamic processes occuring in the atmosphere and oceans.

To achieve these goals, a number of significant objectives have been established for the next decade. These include advancing the understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and their sources in the lower atmosphere; the improvement of operational weather satellite capabilities; optimization of the use of space-derived measurements in weather forecasting; improvements in knowledge of severe storms and forecasting capabilities; a thorough understanding of large-scale open ocean currents, oceans productivity, and air-sea interactions; and an improved knowledge of seasonal climate variability leading to the 'long-term strategy' for climate observations and prediction.

Remote sensing from space is the principal method that NASA uses to accomplish its objectives. Utilization of remote sensing requires a balanced set of activities including: analytical modeling and simulation, laboratory research of fundamental processes, development of instrumentation, flight of the instruments on Shuttle and dedicated spacecraft, collection of *in situ* ancillary or validation data, and scientific analysis of data. The approach is to develop a technological capability and a strong scientific base and then to collect appropriate data (from space and *in situ*) which, taken together, will address a particular program objective.

Our studies of the upper atmosphere have led to a new assessment of the impact of chlorofluorocarbons on stratospheric ozone which was reported to the Congress in January 1982. The revised assessment of the predicted impact is somewhat less severe and resulted from improved measurements in our continuing program of laboratory chemical kinetics measurements. The new model predictions are being tested against our growing set of measurements of stratospheric chemical composition.

Three-dimensional models of the stratosphere are being developed to quantify our understanding of the interrelation of chemistry with dynamics and radiation. The record of satellite ozone measurements now extends for over a decade and is being used in studies to determine if there have been long term trends in the average amount of global ozone which shields the Earth's surface from harmful ultraviolet radiation.

The Upper Atmospheric Research Satellite Experiments (UARSE) activity initiated in fiscal year 1982 will provide a set of satellite instruments capable of making a comprehensive measurement of the state of the stratosphere. Detailed definition studies of sixteen instruments have been completed and a final determination has been made to proceed with development of nine of these instruments.

The Earth Radiation Budget Experiment (ERBE) mission is proceeding on schedule toward a 1984 launch date with a Critical Design Review planned for early 1982. The flight of the Halogen Occultation Experiment (HALOE) instrument has been removed from the ERBE mission and has been selected as a UARS experiment. NASA has continued to support the National Oceanic and Atmospheric Administration (NOAA) by managing the development of the NOAA and the Geostationary Operational Environmental Satellites (GOES) series on a reimburseable basis. NOAA-C and GOES-E were launched in 1981 and preparations are proceeding to launch NOAA-E in mid-1982.

The ability to perform temperature and moisture soundings of the atmosphere from geostationary orbit has been demonstrated by the flight of the NASA-developed visible/infrared spin scan radiometer (VISSR) atmospheric sounder (VAS) instrument on GOES-D and -E. The opportunity afforded by geostationary orbits to observe a localized region continuously will permit intensive study of the evolving temperature and moisture environment of severe local storms. Low Earth orbit sounding capabilities, first implemented in 1978, are now enabling the extension of forecast reliability from three to five days. In certain special situations, reliable forecasts of 8 to 10 days duration have been achieved.

The scientific requirements for a global ocean topgraphy mission (TOPEX) have been reported by a NASA science working group. This mission would measure the global circulation of the oceans for the first time and revolutionize man's understanding of oceanography. A conceptual definition of a space mission to meet these requirements has also been completed.

Virtually all of the data from the Seasat has been archived and much of the Nimbus-7 ocean data has been reduced. Efforts are presently underway to assess the scientific utility of the data. This information is also being used to define potential low cost approaches to using the demonstrated ocean observing techniques to address a variety of ocean research challenges.

Upper Atmospheric Research Program

The upper atmospheric research program is a comprehensive research and technology effort investigating and monitoring the phenomena of the upper atmosphere, aimed at improving basic scientific understanding of the upper atmosphere and methods needed to maintain its chemical and physical integrity.

In particular, the goal of the program is the improved prediction of man's impact upon the ozone layer and the effect of changes in the upper atmosphere upon our environment. In order to accomplish this, efforts are underway: (1) to improve upper atmospheric models, validate them, and assess their uncertainties; (2) to measure minor chemical constitutents, temperature, and radiation fields; (3) to develop sensors capable of remotely sensing all aspects of the upper atmosphere from space; (4) to assemble and maintain the existing long-term data base of stratospheric ozone measurements and long time-scale natural variations in order to detect man-made ozone changes; and (5) to carry out laboratory kinetics and spectroscopy studies to support these activities.

A wide variety of *in situ* and remote sensing instruments which are useful in meeting the objectives related to determining and understanding the distribution of ozone and key nitrogen, hydrogen, and chlorine radical and molecular species in the upper atmosphere have been developed and utilized. These measurements have been made from the ground, from aircraft, balloons, and rockets. An extensive workshop to assess the status of the ozone depletion problem was held in May 1981 (jointly sponsored by NASA and the World Meteorological Organization). This was attended by over 115 scientists from 12 countries.

The balloon support program provides for *in situ* and remote atmosphere measurements in the altitude range of 15–45 kilometers. It also provides partial support for improvements in balloon technology, e.g. the development of truncated duct balloons.

During FY 1983, NASA will continue the assessment and evaluation of man-made and natural perturbations of the stratospheric ozone layer. The development of models (one, two, and three dimensional) which couple radiative, dynamic, and chemical processes will continue; the confirmation of chemical mechanisms by simultaneous measurements of stratospheric trace species using multisensor platforms will be extended (simultaneous measurements of the same species will assist in determining the quality of the data, and simultaneous measurements of different species will improve our ability to critically test our current photochemical theories of atmospheric chemical composition); improvements in the laboratory kinetics and spectroscopy data base will be sought; and improved techniques for detecting additional trace species and remotely measuring winds will be studied. There will also be increased emphasis on the analysis of satellite data sets (Nimbus-6, -7 and Solar Mesosphere Explorer), as well as a modest expansion of research into the mesosphere. Knowledge of the coupling between the mesosphere and the stratosphere is necessary for understanding the complex interactions among radiation, chemistry, and dynamics in the upper atmosphere, and the relationship between solar variations and terrestrial weather and climate.

The balloon program will be continued at a level of approximately 30–45 flights per year and will provide key measurements of the photochemically active trace species important in the stratospheric ozone balance. These balloon flights provide the principal capability to validate the photochemistry program. Balloon flights also provide for instrument calibration and intercomparisons of different measurement techniques. Atmospheric dynamic studies using aircraft and ground-based radar facilities will be continued. Aircraft platforms provide the best method for studying stratospheric-tropospheric interchange and a major study of stratospheric-tropospheric exchange processes is planned in FY 1983. Studies of future instruments will continue our progress toward development of a spaceborne active and passive measurement capability to provide the global data on trace species, dynamic processes, and meteorological parameters needed to understand the atmosphere.

Applied Research and Data Analysis (Environmental Observations)

The applied research and data analysis (AR&DA) activities within the environmental observations program comprise a core of effort which is fundamental to the application of space technology to the Nation's pressing environmental concerns. Atmospheric programs include global weather, severe storms and local weather, and stratospheric and tropospheric air quality. Ocean processes research includes general oceanic circulation, air-sea interactions, ocean productivity studies, sea and glacier ice studies, and marine boundary layer studies. A climate program enables special formulation and study of space-derived data that will interrelate the physics, dynamics, chemistry, and radiation balance of the atmosphere and the oceans in order to understand basic climate sensitivities and to study the requirements for a space monitoring system.

Applied research and data analysis program objectives are to study tropospheric and stratospheric chemical composition and pollution; to model the radiative budget of our planet; to increase our understanding of meterological processes in order to improve numerical weather prediction; to determine the morphology of lightning and severe storm occurrence; and to develop and demonstrate a capability for remotely sensing near-surface properties of the ocean and to relate these properties to characteristics in both the atmosphere above and ocean below the air-sea interface. To study climate, NASA takes a long-term perspective of the phenomena of the atmosphere and oceans with the objective of defining the data requirements, and interpreting the global data sets obtained from spaceborne platforms. Such data are vital to the development of a long-term predictive capability. Each element of the program supports the development and demonstration of remote sensing technology; the development of algorithms to extract geophysical parameters from remotely acquired data; suborbital and ground-based experiments to measure fundamental properties and processes of the environment and provide a base for remote sensor development; fundamental research into the processes at work in the environment; and the development of models which express the current understanding of all or part of this system and provide a predictive capability for key environmental parameters.

Applied research and data analysis activities consist of a comprehensive, integrated program of research, technology, development, measurements, and interpretation. In the AR&DA program, concepts are developed for advanced sensors and advanced studies are conducted for the definition of new systems and missions.

Our studies in stratospheric air quality emphasize accurate measurements and comprehensive ozone analyses. An international rocketsonde intercomparison of several different sensors measuring ozone was successfully completed, the data have been analyzed, and reports are due in early 1982. Comparison of these sensors has established their accuracy and precision for use as "ground truth" for satellite systems. The processed Nimbus-4 and Nimbus-7 backscatter ultraviolet total ozone and upper stratospheric ozone data for the periods 1970–1977 and 1978–1981, respectively, are being used to determine global ozone climatology and to complement the ground Dobson network base. These data sets are also being used to deduce whether ozone (total column content or vertical distribution) has changed between 1970 and 1979. Additional satellite data from the Nimbus-7 and Solar Mesosphere Explorer experiments continue to be collected, processed and interpreted. Stratospheric composition data from the Nimbus-7 and Nimbus-6 experiments are currently undergoing final processing and will be archived for interpretation by the scientific community during FY 1982. Chemical processes will continue to be studied to understand better the atmospheric constituents involved in catalytic cycles that destroy ozone. A hierarchy of models will be developed to explain the chemical, dynamical, and radiative processes of the stratosphere.

Over the twenty years since the launch of the first weather satellite, NASA together with the National Oceanic and Atmospheric Administration (NOAA), has continued the development of an increasingly sophisticated complement of satellite capabilities for the measurement of winds, temperature profiles, sea surface temperature, and other meterological parameters on a routine basis. Hurricanes and storm cells are routinely tracked by images from the Geostationary Operational Environmental Satellites (GOES), and improved forecasts now use the operational temperature soundings.

Recently, a pilot centralized storm information system was established using space-related technology to receive and rapidly display weather satellite data as an aid to short-term forecasts. The Global Weather Experiment (GWE) data have been archived and analysis continues. Over seventy forecast cases based on the GWE data confirm the value of satellite observations in numerical forecasting. An advanced vector processor, now scheduled to begin operating in FY 1983, will enhance our capabilities to assess the role of satellites in forecasting, by using the GWE data, and to provide improved model forecasts in the weather, climate, and upper atmosphere programs. Laboratory studies and modeling improvements continue in several areas such as thunderstorm and tornado prediction. New instruments designed to improve satellite observing capabilities further are already under development.

Preparations are complete for a number of activities to obtain oceanic observations needed to determine the ocean circulation. Seasat data have demonstrated that scatterometer observations enable space mapping of the detailed structure of the ocean surface wind fields, including atmospheric fronts and typhoons. Altimeter observations enable mapping of surface wave fields and circulation features such as the Gulf Stream and mesoscale eddies. Microwave radiometer observations enable all weather mapping of sea surface temperatures and of the characteristics of sea ice. Color scanner observations enable mapping of chlorophyl concentration. Taken collectively, these observations will permit the global determination of the general circulation of the oceans—both the wind-driven and geostrophic components—along with sea ice coverage, sea surface temperature, and primary biological productivity in the oceans.

In FY 1983, basic investigations in research and technology and data analysis will continue in the various discipline areas. Laboratory, field, and advanced studies will address our specific objectives which are to: (1) obtain global climatology of ozone and key nitrogen, hydrogen, and chlorine species in the upper atmosphere; (2) develop a longer-term monitoring strategy for the upper atmosphere; (3) improve our understanding of the chemistry and dynamics of the global troposphere as a crucial element in understanding the whole atmosphere, particularly the stratosphere; (4) improve weather satellite observing capabilities; (5) increase forecasting usefulness of space-derived meteorological parameters; (6) significantly improve our understanding of large scale weather processes and severe storms; (7) improve our storm prediction capabilities; (8) support the National Climate Program (PL-95-367) through studies related to the Earth radiation budget (e.g., ERBE), climate model developments and special studies; and (9) develop an understanding of the ocean circulation and biological productivity of the oceans.

In FY 1983, the stratospheric air quality program will continue to focus on ozone perturbations. Key modeling and analysis efforts and advanced instrument and technique development for field studies will be continued. the major focus will be on: (a) improving experimental techniques which are needed to provide ground truth for satellite systems; (b) conducting a series of intercomparisons of *in situ* and remote balloon-borne sensors for a wide variety of key atmospheric constituents; and (c) increasing emphasis on the interpretation of Nimbus-4, Nimbus-6, Nimbus-7, and Solar Mesosphere

Explorer satellite data utilizing multidimensional theoretical models.

For the tropospheric air quality program, the FY 1983 activities will emphasize development of models for the assessment of the role of the global troposphere as a chemical/dynamical "source and sink" for stratospheric species, development of satellite techniques and strategies for measuring key tropospheric species, and the further development of active and passive remote sensors. This funding will permit further development of aircraft instrumentation and measurements. In addition, support will be continued for laboratory studies to determine rate constants and spectroscopic parameters of key trace species and for planning a global tropospheric experiment on atmospheric chemistry and dynamics.

The activities related to weather and storms will support efforts to improve observing systems and expand uses of existing systems. In the global weather program, development and demonstration of temperature, moisture, and pressure sounders will be maintained. The global weather experiment data sets will be processed and analyzed. The data will be used in the model experiments to assess the impact of satellite data on forecast models and to increase our understanding of atmospheric phenomena. The research program on zero-G fluid dynamic experiments will provide information on the physical processes occurring in planetary atmospheric dynamics which cannot be achieved by any other means. These funds will allow continuation of sensor studies, and supporting laboratory research, and will provide basic data on the dynamics of the atmosphere and oceans.

FY 1983 activities in the severe storms and local weather research program will support techniques to improve the understanding of and, ultimately, the ability to forecast severe weather events. Assimilation techniques for high resolution observations will be tested while new severe storm indicators such as lightning will be studied. Outstanding progress has already been made in developing doppler lidar techniques for the remote measurements of winds. Assessment of the vertical soundings of temperature and moisture from GOES/VISSR atmospheric sounder instruments should provide an evaluation of the validity of the data, as well as an indication of its utility in severe weather forecasting. Other severe storm research will include efforts to improve the basic understanding of storm development and the specific conditions which initiate storms, tornadoes, and damaging downdrafts, and produce destructive cloud to ground lightning. Efforts in the numerical modeling of storms and their environments will be supported in order to enhance forcasting capabilities. The severe storms and local weather research program activities will include: software development for the centralized storm information system program, data analysis and modeling of forecast improvement of tropical cyclones, severe local storms and tornadoes; man-computer interactive data system technique development; storm severity indicator studies; and aircraft data analysis of doppler lidar field experiment measurements.

An advanced high speed vector processor, to be delivered in FY 1983, will greatly improve the presently overtaxed computing capacity. This computer will make it possible to handle and assimilate satellite data more rapidly, to develop more realistic numerical weather prediction models, stimulate advanced observing systems, as well as support other environmental observation programs including climate sensitivity studies and ocean models.

In FY 1983, the oceans research program will include the processing of Seasat data records into final geophysical units and their subsequent analysis; evaluation of the performance of X/L/C-band aircraft synthetic aperture radar in conjunction with the National Science Foundation's warm gulf stream rings and coastal ocean dynamics experiments; characterization of sea ice properties by various remote sensing techniques; definition of altimetry dependence on sea state; investigation of phytoplankton productivity associated with physical and chemical ocean properties near the Grand Banks in cooperation with the National Science Foundation and the National Marine Fisheries Service; refinement of techniques for assimilation of scatterometer winds into numerical models; and development of a shipborne lidar system for depth profile measures of temperature, phytoplankton and zooplankton.

The NASA climate research program, an integral part of the national climate program, will conduct climate parameter sensitivity studies to help establish the requirements for global climate observations, will provide global data sets of satellite-acquired climate measurements (with initial emphasis on radiation budget parameters), and will utilize climate models in order to help define future space observing systems. Specific near-term efforts will include quantitative studies of the effects of clouds and aerosols on climate variations. Planning is underway for NASA participation in the international satellite cloud climatology project designed to produce a five-year global cloud data set needed in developing and validating climate models.

The augmented data processing capabilities at the Goddard Space Flight Center will be utilized for improving numerical climate models, incorporating the results of current theoretical and experimental studies of climate processes, in order to simulate the seasonal cycle and interannual variability of climate. A number of university scientists are participating in collaborative studies with NASA scientists aimed at improving the models needed for these studies.

Shuttle/Spacelab Payload Development (Environmental Observations)

The space transportation system offers the opportunity for frequent, short-duration flights for instruments and associated experiments. The environmental observations program has incorporated this new capability in the Shuttle/Spacelab payload development activities in these important aspects: (1) early tests, checkout and design refinement of remote sensing instruments whose ultimate use will be in long duration free-flying missions; (2) short-term data gathering of atmospheric and environmental information for basic research and analysis where long-term observations are not necessary or are impractical; (3) research into processes which cannot be accomplished effectively in ground-based laboratories.

The measurement of air pollution from satellites experiment is a gas filter correlation radiometer designed to measure the levels of tropospheric carbon monoxide and the extent of interhemispheric mass transport in the lower atmosphere. The instrument was flown on the second Shuttle orbital test flight, STS-2, in November 1981. The instrument performed as expected and obtained approximately 40 hours of data on the global distribution of carbon monoxide in the atmosphere. Long periods of continuous cloud-free data were collected from the northern to southern hemisphere. Three corroborative aircraft flights were made over the east and west coasts of the United States, in addition to a flight over Australia. The measurement of air pollution from satellites experiment has been approved for a reflight and has been assigned to OSTA-3.

The objective of the atmospheric trace molecules observed by spectroscopy experiment is to make detailed measurements of gaseous constituents (e.g., hydrogen chloride, water, ammonia, methane) in the Earth's atmosphere using the techniques of infrared absorption spectroscopy. The data will help determine the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The instrument delivery is scheduled for 1982 with a planned launch in 1984 on Spacelab-3.

In response to an announcement of opportunity, a number of principal investigator class instruments were selected for definition, development and flight as part of the Shuttle/Spacelab payloads programs. Payloads under development include active cavity radiometer-I (ACR-1) designed to determine the total solar irradiance to very high accuracy and precision. This information will aid in studies of the climate and the physical behavior of the sun. The instrument is scheduled to be delivered to the Kennedy Space Center in 1982 for flight on Spacelab-1 in 1983. A program for reflights of ACR-1 is being developed. The experiments selected include reflights of some other instruments flown on the orbital flight test series, Spacelab-1 and Spacelab-2. These experiments are: (1) a solar ultraviolet spectral irradiance monitor; (2) an imaging spectrometric observatory for trace constituent measurements; and (3) a photometric image for lightning research. Several foreign investigations which are complementary to NASA programs have been selected; funding is provided by the foreign agency sponsoring the investigator.

FY 1983 funds will be used to support the Measurement of Air Pollution from Satellites (MAPS) science team activities, data reduction and refurbishment for possible reflight in 1984.

After delivery of the Atmospheric Trace Molecules Observed by Spectroscopy (ATMOS) instrument, a verification and familiarization program will be conducted by the experiment team to establish baseline characteristics of the instrument. Delivery of the instrument for Shuttle integration is scheduled for early 1984 with the initial flight later in 1984.

The Principal Investigator Instrument Development and Reflight Program—the reflights and limited activities associated with development of new principal investigator instruments will continue with research efforts in atmosphere chemistry, solar intensity and variability and upper atmospheric winds in FY 1983. Active Cavity Radiometer-I (ACR-1) funding will provide for data processing and validation, science team activities, and refurbishment for a reflight on a future Shuttle mission.

Operational Satellite Improvement Program (OSIP)

The objectives of the operational satellite improvement program have been to: (1) perform the research and development activities which will provide advanced sensors, spacecraft subsystems, and ground equipment for the operational meteorological satellites, and (2) perform definition studies for incorporation of user-dictated changes which affect the total system configuration and capabilities. Current activities include the following: (1) development of the solar backscatter ultraviolet (SBUV) instrument for future operational monitoring of ozone fluctuations in the upper atmosphere; (2) assessment of temperature and moisture profiles acquired by the visible/infrared spin scan radiometer/atmospheric sounder (VAS) aboard GOES-4 and GOES-5; (3) implementation of improvements in the high resolution infrared sounder (HIRS); and (4) modification and improvement of direct readout equipment for operational use.

Although hampered by the early requirement for operational utilization of GOES-4 and GOES-5, limited experimental results from the VAS instrument show promise for ultimate contributions to severe storm predictions and numerical modeling of weather patterns. We are presently working with NOAA to define ground system modifications and operational time-sharing to allow more opportunities for data-gathering in an experimental mode. The SBUV and HIRS improvement contracts have been signed and are proceeding with development for initial flight on NOAA-F and NOAA-H, respectively.

The FY 1983 estimate is structured to continue NASA's phase-out of this activity. FY 1983 funds to complete SBUV development and improvement of the HIRS instrument are required. NASA will also provide limited support for GOES-G, H, and I modifications required for compatibility with the revised tracking and data system and for ease of operation of VAS in its operational and experimental mode.

Earth Radiation Budget Experiment

More solar energy is absorbed by some regions of the Earth than by others. At the same time, more thermal energy is radiated into space by some regions than others. This differential heating is thought to be the driving force that sets the atmospheric winds and ocean currents into motion transferring heat from warmer to cooler areas. The excess in the amount of solar energy absorbed over the thermal energy radiated to space continually changes for any given region, depending on the time of year, degree of cloudiness, snow and ice cover, abundance of atmospheric dust and aerosols, and properties and conditions of the surface.

The objective of the Earth Radiation Budget Experiment (ERBE) is to measure the temporal and spatial variations in the radiation balance over the globe. General agreement exists within the scientific community that the Earth's radiation budget must be monitored from space if we are to gain basic insight into the reason for climatic fluctuations.

Experimental Earth radiation budget instruments have flown on the Nimbus satellites, and sampling studies based on those experiments have shown that adequate global coverage requires a multiple satellite system. They also indicate the need for improved calibration of the sensors. Coincident Earth radiation budget data sets over one set of seasonal variations are needed. In order to provide concurrent observations from one sun synchronous and one mid-inclination satellite, identical Earth radiation budget instruments will be installed on two satellites of the TIROS-N series and on one dedicated NASA observatory at a mid-inclination orbit. The NASA observatory will be launched between the NOAA satellites to provide the necessary overlap. The scientific objectives and measurement requirements were developed by a combined NOAA/NASA/university/industry team of scientists.

The ERBE instrument contract was awarded to TRW, Inc. in September 1979, and development has proceeded satisfactorily. The preliminary design review was completed in July 1980, and the critical design review is scheduled for early 1982 after completion of engineering model testing. Delivery of the three ERBE instrument flight models is scheduled for 1983.

In addition to the ERBE instrument, the NASA observatory will carry the Stratospheric Aerosol and Gas Experiment (SAGE II). This instrument is being developed by Ball Corporation and will provide aerosol measurement data for ERBE. Both the preliminary and critical design reviews of the SAGE II instrument were completed in 1981. Delivery of the flight model is expected in 1982. 1981 and the critical design review is scheduled for 1982. The ERBS observatory will be launched by the Shuttle to an altitude of 300km and then will be propelled to the operational altitude of 600km by an auxiliary onboard propulsion system.

Due to Shuttle development delays and NOAA FY 1982/83 budget constraints, the planned launch dates for ERBS and for NOAA-F and G, respectively, are under review. Launch rescheduling efforts are underway by both NASA and NOAA in order to obtain the desired satellite schedule overlap for data collection. The Halogen Occultation Experiment (HALOE), which had been intended to fly as an instrument of opprtunity on ERBS, is now a candidate for the Upper Atmospheric Research Satellite Experiments payload.

FY 1983 funding will be used to complete the testing and delivery of the three ERBE flight model instruments for NOAA-F and G plus ERBS. The ERBS spacecraft will be intergrated in FY 1983. Development of algorithms and simulation of data systems operations will also be continued in FY 1983. This activity is designed to insure the ability to reduce and analyze the data before the launch.

Extended Mission Operations (Environmental Observations)

Since the launching of Nimbus-5, -6, and -7 in 1972, 1975 and 1978, respectively, significant quantities of global data on sea ice coverage, atmospheric dynamics and chemistry, the Earth's radiation budget, ocean temperature and ocean color have been gathered. Preliminary evaluation of the results has demonstrated the utility of the measurements, and the instrument techniques are starting to be used on operational satellites. Reduction and validation of these valuable data are continuing, as is the operation of the satellites themselves. There is a strong demand for historical, current and future data regarding global precipitation, soil moisture, snow and ice cover, the Earth's radiation budget, atmospheric dynamics, and trace constituent concentrations and distribution. All contribute toward global weather trend studies, severe storm analysis and prediction, improved numerical forecast models, ozone concentration trend analysis and Earth climate studies.

An important contributor to the ozone and aerosol data base is the Stratospheric Aerosol and Gas Experiment (SAGE) satellite launched in early 1979. The measurements by this satellite of the stratospheric aerosol loading from the Mt. Saint Helens volcano eruptions have contributed significantly to our overall understanding of natural perturbations to the stratosphere and its potential effect on weather and climate. In November 1981, spacecraft experienced operational problems which are currently undergoing engineering assessment.

The Solar Mesosphere Explorer (SME) was launched in October 1981, and is providing major inputs into our overall atmospheric parameter data base. SME is making some of the simultaneous measurements needed to understand the complex chemical processes taking place in the mesosphere. Included in the data set are measurements of ozone, atomic oxygen, nitric oxide and temperature. The four ultraviolet instruments on board are functioning well and data is being returned from the infrared instrument. It appears likely that the mission will continue to operate beyond its one year design life. A ground truth program to verify SME data is being initiated.

Fiscal year 1983 funding will support spacecraft operations, as well as processing and validation of data from Nimbus, SAGE, and SME satellites. These satellites will continue to produce an extremely valuable set of atmosphere and ocean observations during this time period. These observations provide a continued global data set on ozone concentrations. This is required to determine natural variations and long-term trends, sea surface temperatures for real-time operational uses, extended earth radiation budget and aerosol measurements to enhance the interpretation from the upcoming ERBE mission, and coastal zone color scanner (CZCS) measurements which will be used to better predict ocean productivity and carbon uptake. The necessary correlative ground truth activity will also be supported. These *in situ* observations are essential to verify the quality of the observations and improve our ability to interpret them.

Upper Atmosphere Research Satellite Experiments (UARSE)

An Upper Atmosphere Research Satellite (UARS) mission is the next logical step in the implementation of a comprehensive program of research, technology development and monitoring of the upper atmosphere aimed at improving basic scientific understanding. The UARSE program is intended to design and develop the instruments necessary to accomplish the UARS mission and to perform mission definition studies. UARS is planned to provide the first integrated measurements of ozone concentration, concentrations of chemical species that affect ozone, energy inputs, temperature, and winds in the stratosphere and mesosphere. It will extend the measurements of ozone, and of atmospheric parameters affecting ozone, that have been or will have been made on Nimbus and SAGE. It also goes beyond these efforts to measure key species simultaneously in all important chemical families (hydrogen, nitrogen, chlorine, etc.) of the upper atmosphere, dynamic parameters, and solar energy input. UARS is a critical element in NASA's stratospheric research and monitoring strategy. It will provide the first full data set on stratospheric composition and dynamics that will be needed when very difficult regulatory decisions must be made on future production of chlorofluorocarbons. UARS will contribute to the assessment of the impact of stratospheric changes on climate and will provide data needed for a fuller understanding of the stratosphere, which is essential for design and implementation of a long term stratospheric monitoring strategy.

In fiscal year 1980, a tentative selection of 16 experimenters and 10 theoretical investigators was accomplished. Following a 16-month concept definition period, a final selection of 9 experimenters and 10 theoretical investigators was made in December 1981 to start experiment development. The experiments selected are: Solar Ultraviolet Spectral Irradiance Monitor, Ultraviolet Solar Spectral Irradiance Experiment, Cryogenic Limb Array Etalaon Spectrometer, Improved Stratospheric and Mesospheric Sounder, Microwave Limb Sounder, Halogen Occultation Experiment, Temperature and Wind Measurement in the Mesosphere and Lower Thermosphere, High Resolution Doppler Imager, and the Particle Environment Monitor. The Improved Stratospheric and Mesospheric Sounder instrument will be provided by Oxford University, United Kingdom, and the Temperature and Wind Measurement in the Mesosphere and Lower Thermosphere by the Service d'Aeronomie du CNRS, France. These nine experiments draw heavily upon the experience derived from earlier satellites and satellite experiments. The experiments package includes infrared and microwave limb sounders requiring advances in cryogenics, solid-state devices and microwave antennas beyond the earlier capabilities. Final design and development of the instruments and instrument mounting module for the UARSE will proceed consistent with the potential launch of UARS in 1987–88. A launch in that time frame will provide data coverage of the minimum and ascending phases of the solar cycle to complement other data (although more limited) obtained at the maximum and descending phases and will avoid a data gap in the collection of satellite ozone measurements. A ground data handling facility, permitting interactive utilization of data by the Principal Investigators, is being studied as part of the UARSE activity, along with definition of the mission implementation concept. The overall UARS end-to-end data acquisition, processing and distribution system will provide for timely reduction of the UARS data and for their wide dissemination among the UARS investigators.

Fiscal year 1983 funds will be used to support the continued detailed design, development and breadboarding of the selected instruments; instrument module design definition and analysis; detailed mission implementation studies; and definition of concept and design requirements for the advanced ground data handling facility that will be implemented in the UARS program. The instruments are the long-lead time elements of the UARS program. Although there is considerable technological heritage for these instruments, their development and testing in time for a 1987–88 launch opportunity requires that substantial progress in instrument internal design and in interface design—thermal, mechanical, view angles, etc.—with the instrument module take place in 1983.

The ground data handling facility will enable a higher level of interaction among experimenters, and between experimenters and theoreticians than has existed with past programs. Implementation of this concept requires that it be designed early in the UARSE effort so that individual experiment data processing subsystems, including algorithms, can be designed for maximum interaction and effectiveness.

Halogen Occultation Experiment (HALOE)

The objective of HALOE had been to develop an infrared occultation instrument to measure hydrochloric and hydrofluoric acid and other species in the upper atmosphere and to deliver this instrument for flight on the Earth Radiation Budget Satellite (ERBS). Technical problems, schedule delays, and cost increases have resulted in a decision to delete the instrument from the ERBS payload, and to adapt it for flight on a possible future upper atmospheric research satellite mission.

APPLICATIONS SYSTEMS

FISCAL YEAR 1983 FUNDING LEVEL

Airborne instrumentation research program	$11,700,000

The airborne instrumentation research program provides flight support to major segments of the space applications program. The aircraft fleet presently consists of two U–2C's, one ER–2, one C–130, and one CV–990. These aircraft serve as test beds for newly developed instrumentation and permit the demonstration of new sensor concepts prior to their flight on satellites. The data acquired during the flights is used to refine algorithms and develop ground data handling techniques and preliminary proof of concept studies. Examples of such activities are flights over test sites to obtain crop signature data for the AgRISTARS program by the C–130 and flights in the ER–2/U–2C's to acquire simulated thematic mapper data. A principal use of the ER–2/U–2C's is to acquire stratospheric air samples and conduct *in situ* measurements at altitude ranges above the capability of more conventional aircraft and below that of orbiting spacecraft. This use is important in the environmental observation program where much interest exists regarding stratospheric transport mechanisms and where it is extremely desirable to penatrate the stratospheric region, which, in the tropical intercovergence zone, is normally found at altitudes of 60,000 feet and above.

Fiscal year 1983 funds are required to provide the necessary aircraft operations support required by the space applications program.

TECHNOLOGY TRANSFER

FISCAL YEAR 1983 FUNDING LEVEL

Technology transfer	$4,000,000

The technology transfer provides for the development, experimental test and evaluation, and transfer of remote sensing technology applications for operational use by public and private organizations.

User requirements and supporting activities have maintained communications at the national level between NASA and the user community to determine and analyze national priorities and user needs, inform users of existing and planned technological capabilities, obtain external evaluations of technology transfer programs for planning purposes, and develop program awareness and technical capabilities in educational institutions. Cooperative efforts have been conducted with state and local governments to evaluate proven Landsat applications in natural resource and environmental management.

FY 1983 funding will be used to continue these important activities which encourage the transfer of remote sensing technology to public and private organizations.

MATERIALS PROCESSING IN SPACE

FISCAL YEAR 1983 FUNDING LEVEL

Applied research and data analysis	$18,100,000
Shuttle/Spacelab payload development	3,300,000
Materials experiment operations	7,200,000
Total materials processing in space	28,600,000

The materials processing in space program emphasizes the fundamental science and technology of processing materials to understand constraints imposed by gravitational forces and the unique capabilities made possible by controlling these processes in the space environment. Ground-based research, technology development, and payload definition activities in FY 1982 will concentrate on three major processing areas: crystal growth and solidification, containerless processing, and fluid and chemical processing. Limited research will be supported in the areas of cloud physics, combustion science, vacuum science, and fluid dynamics. These activities will provide the scientific basis for future space applications of materials processing technology. Definition study activities will be performed for Shuttle payload candidates such as the acustic containerless experiments system, the combustion science system, the containerless measurement system, and the floating zone experiment system.

The Shuttle/Spacelab payload development project will provide opportunities to perform materials science experiments in an extended, microgravity enviornment. Fabrication and testing of the fluid experiment system, vapor crystal growth (FES/VCG) system and monodisperse latex reactor (MLR) will be completed in FY 1982.

Materials experiment operations is a consolidation of ongoing activities which provide a range of experimental capabilities for all scientific and commercial participants in the materials processing in space program. These include drop towers and aircraft and sounding rocket flights as well as the Shuttle mid-deck experiments and the material experiment assembly. These capabilities will enable users to develop experiments in a cost effective manner and allow NASA to develop a better understanding of the technical risks associated with experiment concepts before attempting to develop more complex hardware. In addition, limited reflight of currently selected investigations on sounding rockets and on Shuttle/Spacelab missions is included in materials experiment operations.

Applied Research and Data Analysis (Materials Processing)

The applied research and data analysis (AR&DA) activity provides the scientific foundation for all current and future projects in the materials processing in space program. The emphasis is placed on ground-based research which is expected to develop into space investigations with potential for future applications. In addition, the AR&DA program supports technology development for future ground and space capabilities, equipment definition studies responding to identified space experiment needs, and commercialization activities leading toward privately funded space enterprises. Most research projects in the AR&DA program are initiated as a result of proposals from the scientific community which are extensively peer reviewed prior to selection. The FY 1982 funding has been used to initiate funding of another set of new three-year research projects proposed by leading members of the materials science community; to initiate new activities in containerless science, cloud physics, and extraterrestrial materials processing; and to begin definition studies in the acoustic containerless experiments system and combustion science facility. Ongoing research concentrates on scientific investigation and technology advancement in infrared detector materials, inertial confinement fusion targets, floating zone crystal growth, separation and synthesis of biological materials, fluid flow effects in materials processes, combustion science, crystal growth, containerless processing techniques, and extraterrestrial materials processing. In addition, some cloud physics research will be initiated as low gravity research opportunities become available. Commercialization activities will continue with studies of institutional arrangements associated with joint NASA/industry ventures, information activities directed toward industry involvement in materials processing in space projects, and negotiations with companies interested in undertaking joint space endeavors with NASA.

Ground-based applied research and data analysis will continue in the areas of containerless processing, crystal growth, solidification, fluid behavior, biological separations, combustion, and cloud physics. Prior material processing in space research has brought three containerless processing techniques (acoustic, electrostatic, and electromagnetic) to the design and trial stage. FY 1983 efforts will include flight test preparation for the first two of these techniques. Fundamental studies of crystal growth, solidification, and fluid behavior will continue in order to define the role of gravity-driven influences (convection, sedimentation, and buoyancy) in generic processing methods, and will concentrate on materials of technological interest (infrared and nuclear detectors, magnetic alloys, and immiscible alloys). Major FY 1983 efforts will also include increasing the scope of materials studied to include superconductors, metallic glasses, and other metastable phases where enhanced or new properties may be achieved. Work will be augmented in the area of bioprocessing by expanding into new separation methods. Companies and arrangements for which space processing and manufacturing are desirable ventures will continue to be identified. A small effort in space materials systems will continue as part of our early study effort for the cost effective utilization of extraterrestrial meterials.

Shuttle/Spacelab Payload Development (Materials Processing)

The Shuttle/Spacelab payload development projects include the design and development of a basic set of payload equipment for space experiments on materials and processes. Experiments are planned with this equipment on space transportation system flights. The first series of experiments to use the equipment will be flown on the Spacelab-3 mission. Investigations selected for these flights cover topics in crystal growth and fluid flow effects. All of the equipment is being designed for repeated use and a long service lifetime, so that it can be used for further experiments on later missions without new development or substantial modification.

Two facility class equipment systems are under development. One of these is a multiuser facility, the fluid experiment system, a sophisticated holographic optical measurement system to determine density gradients and fluid flows during crystal growth and analogous processes. The other facility is the vapor crystal growth system which will grow large single crystals of mercuric iodide by evaporation and recondensation.

The solidification experiment system contract was cancelled in September 1981 due to technical and cost problems. The experimental capacity of the solidification experiment system will be partially recovered by updating existing government furnaces.

The Monodisperse Latex Reactor, planned for flight on a Shuttle orbital test flight, is designed to explore chemical and physical processes involved in forming 10 micron latex spheres in the nearly gravity free environment of Earth orbit.

The development of the fluid experiments system/vapor crystal growth apparatus will be finished in 1982. The fiscal year 1983 activities will concentrate on ground testing by the principal investigators in preparation for a 1984 launch. Initial efforts will be directed toward the growth of infrared and nuclear detector materials in low gravity.

Materials Experiment Operations

Materials experiment operations provide a wide range of opportunities for scientific and commercial experiments in material processing in space. Investigators will gain experience in a cost-effective manner allowing NASA to better understand the technical risks associated with experimental concepts before attempting to develop more complex hardware. Facilities generally in use include drop towers, drop tubes, aircraft and sounding rocket flights. Development of Shuttle mid-deck experiments are also supported under this activity. The first materials experiment assembly hardware will be completed in 1982. In addition, reflights of existing Shuttle/Spacelab facilities and the selection of a limited number of new investigations for the fluid experiment system and vapor crystal growth are part of this activity.

Fiscal year 1983 activities in materials experiment operations will be directed toward new mid-deck experiments, continued use of the materials experiment assembly (MEA–A), definition studies for MEA–C to increase experimental opportunities, and ground-based, low gravity experimentation. The mid-deck experiments will include: (1) investigations using the first version of acoustic containerless processing equipment; and, (2) the first low gravity test of a method (isoelectric focussed electrophoresis) for the separation of biological materials. Development of MEA–B will also allow interfacing to the Shuttle which will provide more energy and cooling capabilities than are possible with MEA–A. Activities in short-term, low gravity ground-based facilities will be augmented, taking particular advantage of the new, longer (91m) drop tube/tower which will become available in mid 1982. This will be used to study the solidification of metastable and deeply undercooled alloys which may possess new and attractive properties.

Communications and Information Systems

FISCAL YEAR 1983 FUNDING LEVEL

Applied research and data analysis	$10,100,000
Search and rescue	3,700,000
Technical consultation and support studies	2,600,000
Experiment coordination and operations support	1,000,000
Information systems	7,500,000
Total communications and information systems	24,900,000

The communications program provides the technology that allows the most effective use of the geosynchronous orbit and radio frequency spectrum. A major portion of the program resources are currently concentrated in the applied research and data analysis element of the program which is focused on new communications subsystem technology. In FY 1980, multiyear contracts were placed with industry to develop a technology base in advanced communications for the 1990's. These efforts, which will be completed in FY 1983, will produce laboratory models of multibeam antennas, onboard switching, signal processing, and radio frequency components. Excellent progress was made on these contracts in 1981.

The search and rescue program uses satellites to aid in the detection and location of distress beacons carried by aircraft and ships. The search and rescue demonstration and evaluation phase will begin in 1982 with the launch of the first United States spacecraft in the series, NOAA–E, and the Soviet satellite, COSPAS 1. During FY 1981, the NOAA–E spacecraft was completed. The search and rescue antennas, receivers, signal processor and transmitter were integrated and tested, completing all necessary preparations for launch. In FY 1982, the ground station development will be completed. Three ground stations will be installed at search and rescue facilities operated by the United States Coast Guard and the United States Air Force. Experimental distress transmitters operating at 406 MHz will be completed and deployed in accordance with the demonstration and evaluation plan. This work will be done in cooperation with Canada, France, and the U.S.S.R. The search and rescue program is now planned to include payloads aboard six meteorological spacecraft operated by the National Oceanic and Atmospheric Administration, and at least two Soviet COSPAS spacecraft.

Technical consultation and support will continue to provide radio interference, propagation, and special system studies required for the growth of existing satellite services and the inclusion of new satellite applications. Support to the Department of State, Federal Communications Commission, and the National Telecommunications and Information Administration, in preparing for a series of World Administrative Radio Conferences on geostationary orbit planning for all space services is continuing, as are broadcast satellite and mobile communications planning activities.

Experiment coordination and operation support was continued for ATS-1, 3, and 5 satellites in FY 1981. The relocation of ATS-1 to enable continued operations in the Western Pacific is now in process. Current efforts are directed at developing protocol user documents to assist other agencies in the use of these satellites for public service.

Information systems will continue to provide timely development of systems capabilities to meet the needs of space science and applications flight missions. Specific examples are the ocean pilot system, high speed processor for Landsat (Thematic Mapper), and common executive software for image processing.

Applied Research and Data Analysis (Communications)

The communications applied research and data analysis program provides the advanced technology base in the field of satellite communications. Currently, there are nine United States commercial communications satellites located above the Equator in view of the United States. Applications are on file for 24 more to be launched by the mid-1980's. These satellites will exhaust the capacity of the geostationary arc at the lower frequency bands currently in use. Capacity increases beyond the mid-1980's will require systems using new technology advances that function most efficiently in higher frequency bands.

In FY 1980 and 1981, a series of technology development contracts were awarded to United States industry to produce proof-of-concept models of components and subsystems that permit satellite communications operations in the new 30/20 GHz frequency band. Contracts have been awarded in the following technology areas: multiple spot-beam spacecraft antennas, spacecraft matrix switch for trunking applications, baseband spacecraft processor, 30 GHz spacecraft receiver, 20 GHz solid state spacecraft transmitter, 20 GHz spacecraft traveling-wave tube amplifier, traveling wave tube power supply, 30 and 20 GHz latching switches, switches and filters for spacecraft-switched multiple access, components for low-cost ground terminals, and spacecraft transponders. Several of these contracts have been jointly funded by the Department of Defense because of their applicability to future military systems. The proof-of-concept models produced by these contractors will be delivered during FY 1982 and FY 1983 and will undergo limited end-to-end testing to evaluate their system level performance.

In FY 1983 the proof-of-concept model technology development program will be completed and a limited laboratory test phase conducted.

Search and Rescue

The search and rescue mission will demonstrate the feasibility of using satellites to significantly improve the capability of search and rescue forces to detect and locate distress signals from general aviation aircraft and marine vessels during an emergency. A satellite system can provide a more comprehensive coverage than the irregular coverage provided by overflying aircraft now relied upon. This permits rescue forces to arrive at the accident scene more quickly than is presently possible. Systems studies have shown that a satellite orbiting at an 850-kilometer altitude can detect the emergency beacons operating at 121.5 and 243 MHz presently carried by aircraft and ships. Systems analysis and simulations indicated that a satellite can fix the position of these beacons to an accuracy of about 15–20 kilometers and could locate a proposed new beacon (using the recently allocated 406 MHz frequency) with its stronger and more stable signal to better than 5 kilometers accuracy.

This multiagency program is being conducted jointly with Canada, France, Norway, and the Soviet Union. The United States will provide the spacecraft, antennas, launch vehicle, and the United States ground stations. The Canadians will provide the space communication equipment and a ground station in their country. France will provide an onboard processor and receiver and a ground station in France. The Soviet Union will launch and maintain in orbit two spacecraft operationally compatible with the United States, French, and Canadian systems, and will operate their own ground stations. Norway will participate in the joint project as an investigator providing additional experimental test beacons and an interoperable ground station in Norway. In addition to NASA, United States participants include the Departments of Defense and Transportation which have purchased and will operate ground stations and will participate in the program test and evaluation phase. NOAA is providing the spacecraft for modifications.

All activities required to support the beginning of the demonstration and evaluation phase of the program in mid-1982 are proceeding on schedule. the NOAA–E spacecraft is complete; the French and Canadian search and rescue instruments have been delivered and integrated; and the spacecraft completed thermal/vacuum testing in November 1981. The three search and rescue ground stations are nearly complete and will be installed in late 1981 and early 1982. The mission control center will be ready in 1982. New experimental distress transmitters operating at 406 MHz have been developed. Excellent progress has been made in developing the detailed test plans which will be used as the basis for evaluating the effectiveness of the system during the 15-month period following launch.

FY 1983 funding will be used to evaluate the performance of the on-orbit search and rescue system to determine overall system effectiveness, location accuracy, and impact on search and rescue operations. FY 1983 funds will also be used to complete the integration and test of the search and rescue instruments on the NOAA-F and G spacecraft. In addition, work will continue on the NOAA-H, I, and J spacecraft to permit an extension of the search and rescue spacecraft coverage on an interim basis until an operational system can be deployed.

Technical Consultation and Support Studies

Radio interference, propagation, and system studies being conducted under this program are required to ensure the growth of existing satellite services and the inclusion of new satellite applications. Unique analytical tools are developed and used to solve problems of inter- and intra-satellite/terrestrial system interference. They provide a technical basis for regulatory and policy studies and are needed to continue orderly satellite services. Emphasis is on orbit and spectrum utilization studies which include the development of frequency and orbit sharing techniques and strategies, design standards, and the determination of the effects of propagation phenomena and man-made noise on performance, design, and efficient use of the geostationary orbit and radio spectrum. NASA's unique resources and expertise, developed over more than 15 years, are also used, on request, to support the Federal Communications Commission, National Telecommunications Information Administration, Department of State, Federal Emergency Management Agency, and other organizations.

Through this program, NASA provided key inputs in the preparation for and participation in the 1979 General World Administrative Radio Conference. More than 100 technical and position papers were provided by this program in support of the 1979 conference.

The program has made it possible to implement, on a commercial and nonexperimental basis, remote sensing, mobile communications, and broadcasting by satellite. These capabilities are essential to a broad range of public and private sector applications such as commerical mobile telephone, direct television and audio broadcast, paging, disaster communications, law enforcement, health and education, interstate commerce, and terrorism control. In a broader sense, the capabilities will be invaluable for domestic and international economic and social development.

Major emphasis over the next three years will include continued preparations for the 1985–87 World Adminstrative Radio Conference on Geostationary Orbit Planning, the 1983 Western Hemisphere Conference on Broadcast Satellite Planning, and the 1983 General World Administration Radio Conference on Mobile Communications, and continued measurement of propagation effects on radio communications.

Experiment Coordination and Operations Support

The objective of this program is to continue experiment support for ATS-1, -3, and -5; and to complete, appropriately document, and archive the wide range of user experiments and demonstrations in the application of satellite communications. Past experiments with

NASA experimental satellites (ATS series and CTS) have generated great interest nationally and internationally in satellite telecommunications. Nearly 400 communication experiments using the ATS series and CTS have been successfully conducted during the extended lifetime of these satellites to provide users with the experience necessary for making decisions regarding their communication functions. NASA's stimulus in encouraging use of these unique facilities has led to wider use of commercial satellites, which can now better meet needs for flexibility and continuity of service. ATS-1 and ATS-3 are currently used for VHF communication experiments in health care delivery, education, public safety, emergency communication, mobile land and maritime communications, research support and data communications. The major experiments on ATS-1 involve communications in the islands of the Pacific Basin, and for much of that region, the ATS-1 is the only source of intra-island communications.

A major accomplishment of this program was the completion of the first phase of the Pacific Basin Communications Study, partially funded by the National Telecommunications Information Administration, which assessed present telecommunication systems in the Pacific island regions, examined user needs and services, and proposed alternative technological solutions for a regional satellite based communications system.

Other activities in this program include planning for educational and public service communication, continuing support for the management and operation of the Denver Satellite Access Facility and the coordination of ATS user experiments with other Federal agencies.

ATS-1, 3, and 5 operations will continue through the end of 1983 as will Denver Satellite Facility support. The Pacific Basin Study will conclude with an evaluation of the technical characteristics of a Pacific island satellite based telecommunications network. A study of ATS-1 follow-on options and alternative low density system concepts will be conducted.

Information Systems

The objectives of the information systems program are to develop and demonstrate advanced capabilities for managing, distributing, and processing data and information; to implement information systems standards and transportable common software to lower data systems costs; and to develop the basis for data services to provide improved access to, and rapid delivery of, space data and information in support of the Nation's satellite programs. Further objectives of this program include the improvement of capabilities for analyzing, managing and exchanging data and information in support of Space Science and Applications projects.

This program provides for timely development of data systems capabilities to meet the needs of flight missions and major space science and applications programs. The early demonstration of capabilities has a good potential of reducing ground data systems development risks and the incidence of schedule slips and late data delivery. The results of the 1983 efforts will provide for an earlier return on the considerable investment in data acquisition, will establish a firm basis for interagency data sharing, and will result in compatible data and data systems. Pilot data systems projects (initiated in 1981 in the atmosphere, oceans, and resources disciplines) will demonstrate common multidisciplinary approaches for cataloging, processing, managing, and using science and applications data.

The 1983 information systems program will provide near-term support for space applications programs. Specifically, funds will be used to complete one of the pilot projects (development of an advanced pipeline processor system that will support the Landsat Thematic Mapper); continue development of the ocean and atmospheric pilot systems at the Jet Propulsion Laboratory and the Goddard Space Flight Center; and complete implementation of online catalogs and common software for climate and oceans data to support ongoing discipline research.

The 1983 program includes the completion of the applications data systems (ADS) definition studies; supports the continuation of the atmosphere and oceans pilot data systems through completion; provides for the interconnection of these pilots to form the nucleus of an ADS; provides for technical support of flight projects; continues high priority data system standards and transportable software research and development activities; and allows the definition of joint pilot activities with the National Bureau of Standards and the National Oceanic and Atmospheric Administration.

8. TECHNOLOGY UTILIZATION, $9,000,000

FISCAL YEAR 1983 FUNDING LEVEL

Technology dissemination	$3,200,000
Technology applications	5,800,000
Program evaluation and support	....
Civil systems	....
Total, technology utilization	9,000,000

The NASA technology utilization program is designed to enhance national economic growth and productivity through the transfer of new technology resulting from NASA research and development programs to the nonaerospace sectors of the economy. In addition to generating use of aerospace technology in United States industry, such technological advances have found use in important public sector areas such as medicine, transportation, environment and public safety. The specific objectives of the program are:

To accelerate and facilitate the application and use of new technology thus shortening the time between development of advanced aeronautics and space technologies and their full use in the economy;

To encourage multiple secondary uses of NASA technology in industry, education, and Government where a wide spectrum of technological problems and needs exist;

To understand more fully the technology transfer process and its impact on the economy, and to manage and optimze the process in a systematic way; and

To develop applications of NASA's aerospace expertise—its technology, technologists and unique facilities—to nonaerospace needs of the Nation.

Since the program's inception in 1962, a multifaceted array of transfer mechanisms has evolved—mechanisms designed to facilitate the use of aerospace technology in the public and private sectors of the economy. These mechanisms or project areas include: publications and announcements, industrial applications centers, the Computer Software Management and Information Center (COSMIC), State technology application centers, applications teams/applications engineering and civil systems projects.

Subscriptions to NASA Tech Briefs among engineers, scientists and businessmen in United States industry reached the administrative limit of 75,000 distributed copies during the past year, necessitating the establishment of a "waiting list" pending completion of annual circularization. Nearly 160,000 requests for additional technical information were received by NASA during the past year based on Tech Brief announcements, reflecting substantial continued industrial interest and utility of this primary NASA transfer mechanism.

Last year, the NASA dissemination center network continued to provide United States industry with technology research and assistance service based on problem-related inquiries from client firms. Companies, both large and small, found such services to be especially beneficial in the development of new and improved products and processes. In addition, use of government-developed computer programs made available through the NASA-sponsored Computer Software Management and Information Center (COSMIC) reached an all-time high with industrial income for programs reaching the $730,000 level—a 35-percent increase over the previous year. Total industrial income from NASA dissemination center activities was $4,100,000 last year, a 22-percent increase over the previous year.

Program evaluation efforts were substantially reduced last year due to the FY 1981 rescission and are now incorporated in the dissemination line which they support. Evidence of technology transfer continued to be systematically documented for use in the annual "Spinoff" report to industry and the public, a publication which has created broad awareness of NASA research and development programs and the beneficial uses thereof in the United States economy.

During 1981, applications engineering project emphasis was directed to bioengineering, rehabilitation, environment and public safety problems. Each of the 25 projects funded last year had joint participation from user agencies or industry. A major milestone was reached in bioengineering when the programmable implantable medication system was successfully implanted in a diabetic animal. Also, a mass spectrometer study was completed for the National Institute for Occupational Safety and Health and NASA and the National Institute of Handicapped Research successfully demonstrated a new wheelchair concept for possible use in commercial air travel.

During 1981, the civil systems program was brought to a conclusion. A total of 18 projects were completed during the period of 1974–1981. Of those 18, eight have already reached a successful transfer to the public sector. Projects demonstrated in this program area covered water and air pollution, undersea technology, radar archaeology, agro-environmental systems, and radar entomology.

TECHNOLOGY DISSEMINATION

In FY 1983, NASA will continue efforts to meet the requirements of the Space Act to provide for the widest practicable dissemination of technical information resulting from NASA research and development programs. Funding in FY 1983 will continue the dissemination of information concerning NASA technology but at a somewhat lower level than FY 1982. NASA will attempt to maintain price levels for technical information for United States industry so that access by small business users will not be seriously impaired.

In FY 1982, NASA will perform its evaluation and benefit analysis activities to analyze areas of United States industrial need where aerospace technology may have particular applicability. In addition, program elements will be reviewed in detail to determine the practicality of greater private sector involvement in the technology transfer process. Benefit and economic impacts resulting from NASA research and development programs will also be analyzed, documented and assessed to determine appropriate changes to make the program more effective. In FY 1983, program evaluation and benefit analysis will be phased out; however, publication inquiry support and scientific and technical information data base support for the NASA dissemination center network will be maintained at the NASA scientific and technical information facility.

TECHNOLOGY APPLICATIONS

In FY 1983, NASA plans to focus its applications engineering program in the biomedical field. NASA will continue participation to completion of several high priority biomedical projects and maintain biomedical applications team activities in support of selected feasibility studies designed to apply existing aerospace technology to biomedical problems identified in cooperation with the National Institutes of Health and other public sector medical organizations. NASA will also continue applications engineering in other areas such as transportation, manufacturing, environment, and public safety.

PROGRAM EVALUATION AND SUPPORT

Activity formerly funded under this title has been incorporated into technology dissemination which it directly supports.

CIVIL SYSTEMS

The civil systems program was brought to a conclusion during FY 1981. A total of 18 projects were completed during the period of 1974-1981. Of those 18, eight have already reached a successful transfer to the public sector.

9. AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM, $267,100,000

FISCAL YEAR 1983 FUNDING LEVEL

Research and technology base	$188,000,000
Systems technology programs	79,100,000
Total aeronautical research and technology program	267,100,000

The objectives of the aeronautics program are to advance aeronautical technology to insure safer, more economical, efficient, and environmentally acceptable air transportation systems which are responsive to current and projected national needs; to support the military in maintaining the superiority of the nation's military aircraft; and, to maintain the strong competitive position of the United States in the international aviation marketplace.

The FY 1983 program supports these objectives by providing for technology advances in all aeronautical disciplines, stressing the technology areas judged to be the most critical by in-house assessments, industry, military, and advisory groups, and other users of technology within and outside the Federal government. Emphasis will be placed on maintaining a strong discipline- and vehicle-oriented research and technology base, with focused systems technology programs in a variety of flight categories.

RESEARCH AND TECHNOLOGY BASE

FISCAL YEAR 1983 FUNDING LEVEL

Aerodynamics research and technology	$42,300,000
Propulsion research and technology	43,000,000
Materials and structures research and technology	31,300,000
Aircraft controls and guidance research and technology	12,900,000
Human factors research and technology	9,600,000
Multidisciplinary research	3,500,000
General aviation and commuter research and technology	....
Low speed research and technology	12,400,000
High speed research and technology	27,000,000
Transport research and technology	....
General augmentation	*6,000,000*
Total	188,000,000

Aerodynamics Research and Technology

The objectives of the aerodynamics research and technology program are to: (1) increase the capability to predict the complex aerodynamic flow over aircraft and missile components; (2) discover new means for increasing aerodynamic performance; and, (3) provide for the development of aerodynamic facilities and measurement techniques.

Aerodynamic predictive capability continues to improve with new developments in numerical analysis and in the application of more powerful computers to aerodynamic problems. The computation of transonic flow with shock-boundary layer interaction on airfoils, which is critical in the design of advanced transport aircraft, is becoming a precise science. Substantial progress has been made in computing flows over airfoils at high angles of incidence where the flow may become oscillatory and shed vortices into the wake. New approximate methods have been developed and published for computing the flow-over-wing, body, nacelle, and winglet combinations thus permitting a substantial reduction in wind tunnel time for developmental testing.

Potentially significant discoveries are being made during FY 1982 in devices and surface treatments capable of reducing the turbulent friction drag of fuselages and wings. These experimental findings will permit total aircraft drag reductions of 10 to 15 percent if early results are confirmed.

Such devices may be retrofitted to the existing fleets of aircraft and missiles. New capabilities for testing multielement airfoils to increase maximum lift have been developed during the year. A modified wind tunnel, known as the Low Turbulence Pressure Tunnel, will be used to develop a new series of natural laminar flow airfoils which apply to general aviation and commuter aircraft. The National Transonic Facility (NTF), which will provide the Nation with the world's most advanced high Reynolds number wind tunnel, is expected to achieve operational status at the end of FY 1982.

In FY 1983, program funding will be increased to accommodate: (1) operation of the NTF, (2) continued lease of a Class VI computer at the Ames Research Center to replace the obsolete ILLIAC system; (3) continuing studies of the Numerical Aerodynamic Simulator system; and, (4) activities to investigate stall/spin and natural laminar flow phenomena for general aviation-type aircraft.

The research program during FY 1983 will emphasize the application of new computational methods and high speed computer system architectures to practical aerodynamic problems including the task of determining optimal geometries for wing sections and combinations of aircraft components. Additional work will be directed toward the generation of high-lift airfoils and wings that provide opportunities in aircraft design for improved range and fuel economy.

A strong effort will be maintained to verify and exploit newly discovered friction drag reduction techniques for turbulent flow over wings and fuselages. The basic theory for the reduction of the transition of laminar flow into turbulent flow will be confirmed. The research will provide the fundamental technology for future design of laminar flow systems at both subsonic and supersonic speeds.

Theory and the experimental data base for achieving efficient supersonic and hypersonic flight will be augmented during FY 1983 to support national efforts to improve the range and flight performance of military aircraft and missiles.

With the NTF achieving operational status, comparisons of transonic flight and wind tunnel data will be possible in ranges of Reynolds numbers not heretofore achievable. During FY 1983, new exploratory models designed for the stringent cryogenic test environment will be tested to provide preliminary high Reynolds numbers data and to confirm model and measurement system design techniques. Further development of cryogenic testing will address the unsteady aerodynamic problems of aileron buzz and wing flutter at flight Reynolds numbers.

Wake vortex studies will be continued and broadened to identify differences in structure between wakes that have been highly attenuated and those produced by conventional wings in landing configurations. The Wake vortex Facility, at the Langley Research Center, will be used for tests conducted at a small fraction of the cost of flying and modifying existing large aircraft to achieve similar test conditions.

Stall/spin research will concentrate on the development of analytical prediction methods, aided by the extensive experimental data base accumulated in past years. Research on natural laminar flow phenomena will pursue practical methods for incorporating means for overcoming or avoiding adverse environmental effects (ice formation and insect contamination) and will study three-dimensional wing design requirements and limitations. Other drag reduction research will continue to study ways to reduce undesired aerodynamic surface interference effects.

Propulsion Research and Technology

The objective of the propulsion research and technology program is to provide the fundamental understanding and generic technology that will allow continued future improvements in aircraft propulsion system efficiency, engine performance, fuel flexibility, reliability, and durability as well as environmental compatibility. The potential of advanced propulsion system concepts is also evaluated within the program. Research is being performed in the areas of turbomachinery, combustion and fuels, propulsion system integration, power transfer, engine systems, controls, noise, computational methods, and instrumentation. These activities provide the fundamental understanding and technology advances that will lead to propulsion system improvements for a broad range of vehicle applications ranging from small, general aviation aircraft to commerical transports and helicopters to military aircraft of all types.

Advanced analysis codes which model internal flows in advanced gas turbine engines are receiving continued emphasis. When fully developed, these codes will have significant potential for reducing development time and cost, as well as providing for improved performance of advanced engines. In FY 1982, three-dimensional inviscid flow analysis codes are being extended from fans and compressors to include turbines. Turbomachinery research continues to explore basic fluid mechanics and heat transfer. Detailed boundary layer and secondary flow measurements are being obtained in cascades and large low speed rigs to verify existing analytical codes. Experimental evaluation of geometry and endwall effects on the performance of small turbomachinery components continues. Investigation of stall performance and recovery characteristics of highly loaded compressor stages is being conducted for dynamic modeling of compressors. Progress has been made in identifying the multiple sources of fan noise and quantifying the influence of forward velocity on fan noise generation. New emphasis is being directed toward identifying noise generation mechanisms of rotors and high speed propellers. In combustion and fuels research in FY 1982, increased emphasis is being placed on understanding fundamental processes and development of analytical models. Experimental investigations of fundamental hydrocarbon reaction rates are being conducted to determine soot formation mechanisms over a range of temperatures and pressures typical of combustor operation as a function of hydrocarbon type. The data is being used to develop multistep kinetic models of the soot formation process. Work continues toward establishing a data base on fuel effects in FY 1982 through an experimental program to relate fuel characteristics (viscosity, composition, hydrogen-carbon ratio) to combustion stability, ignition, emissions, and flame radiation. As a result of propulsion system integration research, an experimentally validated viscous, three-dimensional, patched code for the prediction of exhaust system performance will be available for industry use during FY 1982. Increased emphasis on propeller aerodynamics has resulted in improved flow analysis codes for describing propeller performance for a wide range of applications. Experimental verification of these advanced codes has been initiated in FY 1982. Research on propulsion controls is ongoing to develop a real-time steady-state and dynamic engine simulator for use in future control research. With the simulator design completed, fabrication is being initiated in FY 1982. Future research in this area may ultimately lead to a miniaturized engine-mounted simulator for onboard diagnostics and adaptive control capability. Efforts in power transfer research are focused on developing and verifying improved computational techniques for analysis of lubricated contacts, transient rotor response, gears, and high speed rolling element bearings. Lubrication analysis for high speed gear mesh lubrication and multigear mesh dynamic analysis will be completed in FY 1982. Instrumentation research is concentrated on the measurement techniques required for higher pressure and temperature environments typical of future propulsion systems. Recently developed nonintrusive techniques for gas path flow measurement and visualization are being used to verify advanced analysis codes.

Broad property fuels research focuses on evolving and evaluating combustion technology to accommodate future fuels. The initial concept definition and evaluation phase of this activity has been completed. Design refinement and optimization of multizone (double-annular) and variable geometry combustor concepts are in progress.

In FY 1983, the scope and funding of propulsion research and technology base effort will be expanded by $3.5 million to include technologies in advanced propeller concepts, as well as rotary and reciprocating engines. The integration of noise reduction, composite structures, and increased aerodynamic efficiency technologies will be undertaken for advanced propeller concepts applicable over the broad range of general aviation and commuter transport aircraft. Engine research will continue the evolution of enabling technologies for superior rotary and reciprocating engines having multifuel capabilities. Research in computation fluid mechanics will continue the development of advanced analysis codes which model complex internal flows in advanced propulsion system components.

The Lewis Research Center computational capability will be upgraded to support the increased emphasis on fundamental computation fluid dynamics research and, more specifically, the future focus on complex, three-dimensional viscous internal flows. The capability of existing inviscid flow codes will be extended by the incorporation of viscous/inviscid interaction corrections.

Turbomachinery research will continue to focus on fundamental heat transfer and fluid mechanics experiments with emphasis on boundary layer behavior, secondary flows, scale effects, and rotational effects for flow physics modeling and code verification. Investigations of in-stall performance and recovery characterists of advanced highly-loaded compressor stages will continue.

Combustion and fuels research will continue to be directed toward achieving a basic understanding and analytical representation of the fundamental aerodynamic and chemical kinetic phenomena governing the combustion process. Specific emphasis in FY 1983 will be given to improving and validating turbulent flow field models, droplet combustion, and kinetic computations. In FY 1983, increasing emphasis will be directed toward critical aircraft resources technology with the principal emphasis on developing the fundamental data base relating fuel chemistry to physical property variations and ultimately to effects on combustion, emissions, and component performance and durability.

In FY 1983, the focus in noise research will shift from turbofan application to the fundamental understanding of source noise of rotors and high speed propellers. This will lead to development and validation of source noise prediction models that can ultimately provide a design-for-noise capability for turboprops and rotorcraft.

Propulsion system aerodynamics research will concentrate on analytical methods and verification for supersonic inlets, diffusers, turboprop/airframe integration, and advanced propellers. In FY 1983, verification of three-dimensional nonviscous and viscous aerodynamic codes will be initiated using flow field data obtained through advanced nonintrusive measurement techniques. In FY 1983, engine systems and controls research will focus on the funamental understanding and modeling of turbofan stall recovery. The use of advanced control modes will be examined as a method to effect recovery from turbofan hung stalls. Initial efforts will begin to prepare the hardware developed during the energy efficient engine program as testbeds for future engine systems research.

Advanced propulsion systems research will continue to pursue activities to gain an understanding of the fundamental processes associated with hypersonic propulsion. Computational methods will be developed and validated to predict the characteristics of turbulent combustion flows. The focus in FY 1983 will be on demonstrating useful levels of installed thrust and impulse for a single subscale engine module over a range of Mach numbers from 4 to 7.

Within instrumentation research, increased emphasis will be placed on combustion diagnostic techniques to acquire and process large amounts of data for validating analytical models of physical processes.

Mechanical power transfer research will continue to advance the fundamental understanding of lubrication and wear mechanisms and the technology of bearings, gears, seals, and lubrication systems to achieve increased life, performance, and efficiency in the high speed, temperature and pressure environments of advanced gas turbine engines and mechanical transmissions. Increased emphasis will be placed on extending the technology base of large, high speed gear and lubrication systems to improve the understanding of the effects of scale.

Materials and Structures Research and Technology

The objectives of the materials and structures research and technology program are to: investigate and characterize advanced metallic, ceramic, polymer, and composite materials; develop structural concepts and design methods to exploit the use of advanced materials in aircraft; further analytical and experimental methods for determining the behavior of aircraft structures in flight environments; and, generate research data to promote improvements in performance, safety, durability, and economy in civil and military aircraft. Areas of emphasis include high temperature engine and airframe materials and structural concepts; composite materials application, life prediction, thermal and dynamic response, and aeroelasticity; and more accurate and efficient integrated design methods for airframes and engines. During the past year, advances were made in understanding the role of the critical strategic element, cobalt, in high temperature superalloys. Coating development work has demonstrated an increase in temperature capability of coatings and the ability to model the oxidation/corrosion environment encountered in turbine engines. Life prediction methodology continued to make advances in modeling of viscoplastic behavior of a metal subjected to cyclic high temperatures and stresses. Initial research on advanced powder aluminum alloys has demonstrated improved temperature and strength properties. Advances are also being made in the capability to predict the life of composites which will improve the efficiency and performance of aeronautical systems. In composite structural applications, concepts for improving damage tolerance by means of buffer strips, bonded stringers and translaminar stitching have been validated. Intensive studies of impact response characteristics and delamination behavior and control have been initiated. Efforts to develop tougher resins have resulted in the identification and initial assessment of promising compositions, such as rubber-toughened epoxy, novel on-phase thermosets, and modified thermoplastics.

Research has continued in the area of improved optimization and design-oriented analysis methods. A wide collection of analysis codes has been developed and assembled. The codes are being integrated into a computer application system for the evaluation and design of a wide range of aerospace vehicles. Studies of the use of microprocessors for structural calculations have resulted in a successful demonstration of a prototype hardware configuration and solution algorithms. Further research will define key components that can improve hardware and software design and efficiency.

In FY 1983, the program will be expanded to include the critical safety related research in meteorological hazards, fire safety, and landing systems previously conducted under transport research and technology, and the crash dynamics and composites materials research previously conducted under general aviation and commuter research and technology.

Research in structures will continue the evolution of design methodology for optimal crash load limiting structures for general aviation, thereby extending this effort into the realm of composite materials. Focused research in composites for light aircraft will be initiated based on previous study determinations.

Research in aircraft landing systems will continue studies of the effects of tire failures on aircraft controllability. Long-term studies of tire behavior and optimized design will begin using inputs from the tire thermal, friction, and wear studies that will have been completed. Development of advanced elastomers for tire carcasses will continue based on tire tread experience. An in-service evaluation is planned. Development of the ground handling simulator will continue based on completed research in antiskid and brake systems and aircraft performance on slippery runways. Advanced antiskid systems development will begin.

Research on high temperature materials will continue to emphasize improving the strength and service life of gas turbine materials. During FY 1983, research in fiber-reinforced superalloys will be directed at improved processing techniques and modeling of material response under thermal loadings.

Research will continue to focus on obtaining a fundamental understanding of the roles of cobalt, columbium, and tantalum in superalloys. Work on advanced thermal barrier coatings of greater durability will continue. Life prediction of materials using viscoplastic modeling techniques will be continued. The powder aluminum program for high speed airframe structural applications will increase in scope to include the addition of silicon carbide particulate for increased strength and stiffness. Research on material response to cyclic loading and resultant fatigue/fracture behavior will continue to be a major thrust in airframe materials.

To predict service durability of composites, a damage growth law will be developed and validated. Research on composites will continue to emphasize the evaluation of stiff, lightweight structural materials. In FY 1983, studies will continue on low cost fabrication processes and applications of composites in fixed-wing aircraft. Study emphasis will be placed on processability improvements and methods for evaluating and increasing the durability and damage tolerance of second generation composites. Exploratory research will be continued on new resins that will result in tougher, impact-resistant, more processable composites. The fabrication and evaluation of advanced composites for high performance engine blades will continue in FY 1983.

In loads, dynamics, and aeroelastic research, the FY 1983 program will continue to validate improved unsteady aerodynamics prediction methods, with major emphasis on the transonic speed range, based on both frequency and time domain computational techniques. Aeroelastic analysis tools will be developed for application to wings and to turbine engine fans, compressors, and turbine blades, and validated by means of experimental data from wind tunnels, spin rigs, cascade rigs, and flight tests. Concepts for active and passive control or aeroelastic behavior will be investigated and validated. Investigation of active controls applications to forward swept wing design will be initiated. Methods for the prediction and control of structure-borne aircraft interior noise will also be developed. In transport crash dynamics, a crash scenario will be defined based on the various crash scenarios developed in FY 1981 and used to establish requirements for the joint NASA/Federal Aviation Administration full-scale 720 transport crash test. The evaluation of modeling techniques for crash response prediction will continue. Additional effort will define component and scaled model tests for concepts and prediction methods validation. In FY 1983, work related to integrated analysis/synthesis methods will focus on the optimization of the structural and aerodynamic configurations and the performance attributes of airframes that incorporate new technologies such as active controls and advanced composite materials. A large-scale optimization of a transport aircraft wing for fuel efficiency has been defined as a long-term task on which to focus the new methodology development. An ongoing program to demonstrate a finite element machine computation device using microprocessor components will continue. A 36-node board system will be fabricated and used for performance evaluation of a finite element machine prototype design.

High temperature structures research will continue to develop nonlinear analysis methods for predicting the response of airframe components subjected to transient thermal loads, and for predicting the useful structural life of turbine engine hot section components. Concepts for improving the thermostructural efficiency of such structures will continue to be investigated and validated.

Aircraft Controls and Guidance Research and Technology

The objectives of the aircraft controls and guidance research and technology program are to: provide fundamental knowledge and understanding of information and control theory for analyzing the performance of aircraft; develop mathematical control laws and design methods for extending the performance envelope and reliability of future civil and military aircraft; devise analytical methods and techniques for assessing the performance of large-scale, complex integrated systems; and, investigate emerging technologies which offer future alternative approaches for continued aviation safety and efficiency. Major program elements are; applied control theory, flight path management, flight-crucial systems which include fault-tolerant architectural concepts, system assessment methods, and environmental effects research.

Needed advances are being made in the determination of design criteria for vehicles with highly-augmented controls. Shuttle data is being analyzed to assess the flying qualities and improve the generic design process and modeling techniques. Improvements in analytical techniques are providing the capability to determine the influence of different active control concepts on aircraft stability, performance and configuration. Experimental flight tests are being conducted to validate advanced control laws which improve aircraft performance in the presence of gusts, clear air turbulence and other disturbances without limiting the control system effectiveness in other flight regimes. A multispectrum guidance concept using image processing and terrain matching techniques is being investigated for highly accurate approach and landing operations. This could prove to be particularly important in remote site activities.

Flight-crucial systems research is a major element in the controls and guidance program. Continued progress is being made to provide the needed technology base. In FY 1982, a technique to protect electronic systems against latent generic software errors is being evaluated. It uses dissimilar software embedded in the primary system and will potentially eliminate the requirement for costly, complicated backup hardware currently used in aircraft systems. Concern with the effects of lightning on digital electronics has increased research activity both in understanding lightning phenomena and in developing protective techniques. The effectiveness of newly developed protective schemes is being evaluated using induced voltage levels determined from prior studies. Other activities in this area have resulted in a system for random injection of lightning-induced upset transients into microprocessors to characterize the effects.

In FY 1983, critical safety research previously conducted under transport research and technology will be conducted as an integral part of the aircraft controls and guidance research and technology program. Emphasis in FY 1983 will also focus on research in flight-crucial controls technology and applied control theory.

In the flight-crucial systems area, ongoing fault-tolerant control system studies will be expanded to define a candidate system architecture and to conduct laboratory simulations to assess the reliability of a fault-tolerant control system. Research on reliable flight software will continue to emphasize methods for establishing complete and consistent specifications to avoid errors. Results of these activities will be analyzed through laboratory simulation facilities to evaluate system effectiveness in FY 1984. With the opening of a new electronics research laboratory, called Avionics Integrated Research Laboratory (AIRLAB), at the Langley Research Center and the trend toward complex, highly integrated systems, increased emphasis will be placed on the development of systems validation methodology. Initial checkout of AIRLAB will utilize a well defined and tested digital system as a baseline to conduct laboratory experiments for verification and calibration. In addition, the Langley Research Center's advanced operating system research aircraft will be used, as appropriate, as a companion facility to support this activity. Research efforts in fiber optics technology and lightning effects will continue to contribute concepts to the fault-free technology base.

Research in meteorological hazards to aviation will continue using two flight research aircraft to characterize severe storms and the effects of lightning and turbulence on future aircraft systems design and operations. Dissipation of warm fog using the charged-particle concept will be evaluated in the field. Icing research will include development and evaluation of improved icing sensors, scaling laws and the study of modern airfoils under icing conditions. Improvements in wind tunnel productivity for icing experiments are planned using improved aerodynamic measurement devices.

In FY 1983, a more concerted effort will be initiated to establish design criteria and an optimized mechanization process for interdisciplinary active controls. Initial emphasis will be on the development of improved techniques for analyzing the functional interplay between disciplines.

Human Factors Research and Technology

The objective of the human factors research and technology program is to provide the supporting data base and advanced technology for solution of human factors problems which influence the growth, efficiency, and safety of air transportation. The program has two major areas of emphasis: flight management and flight simulation technology.

In the area of flight management, the activity to assemble, analyze, and report the available practical knowledge on the effects of circadian desynchronosis has been completed. Data on actual crew rest and dietary patterns are now being collected. A number of significant experiments have now been completed under the joint NASA/Federal Aviation Administration cockpit display of traffic information (CDTI) program. The effects of sensor noise, size of display, intrail spacing stability, and various candidate procedures have been studied, and an assessment of potential advantages and disadvantages of these and other variables will continue. Investigation of the human factors effects of increased automation in aircraft and the air transport system is being emphasized.

In FY 1983, single pilot cockpit display technology efforts previously conducted under general aviation research and technology will be conducted as an integral part of this program. Also, the flight management research program will continue to emphasize CDTI, aircrew performance, and advanced crew station human factors. The joint NASA/FAA CDTI program encompasses multiple simulator studies of pilot ability to use the CDTI to assume certain air traffic control functions. A primary emphasis of the work will be an investigation of the interactive effects of CDTI with other planned innovations such as collision avoidance systems and automatic traffic advisory and resolution service. The FY 1983 activities will address the critical questions affecting the earliest possible implementation decision.

In the area of aircraft performance, efforts in crew resource management and circadian desynchronosis will increase the knowledge of the causes of human error in aviation, especially as it pertains to decisionmaking and problem-solving under stress. Increased emphasis will be placed on the generation of crew workload and performance measures. Circadian desynchronosis work will focus on laboratory investigations and appropriate field studies of the effects of the dietary and rest patterns of airline crews. These efforts are designed to assess the range and extent of circadian desynchronosis effects, develop methods of minimizing those effects, and determining crew tolerance limits.

Advanced crew station human factors efforts will emphasize the generation of guidelines for aircraft systems and operations tolerant to human error based on earlier exploratory work defining the proper role of automation in the cockpit. Candidate automation guidelines will be evaluated under controlled conditions in high fidelity, full-workload simulators with integrated air traffic control simulation. Conditions which lead to accidents will be recreated through simulation, and the effects of various degrees and types of automation will be studied. A corollary of this work will be an investigation of the roles of aircraft crews under conditions of increased automation.

Flight simulation research for the multicab simulation facilities being developed at Ames Research Center, (the Man-Vehicle Systems Research Facility) and at Langley Research Center, (the Mission Oriented Terminal Area Simulation), will address the development of research methodologies which can take maximum advantage of the new multicab technologies for increasing simulation fidelity will continue.

Multidisciplinary Research

The objective of the multidisciplinary research program is to conduct novel, long-range, multidisciplinary research related to aeronautics. This research is conducted principally at universities through: (1) the Fund for Independent Research which supports unsolicited proposals and proposals received in response to announcements of research opportunities in specific areas, such as physics of compressible flowing fluids, mechanics of turbulent momentum transfer, coherent vertical structures in turbulence, investigation of laser beam molecular interactions, condensation of pure gases, combustion chemistry, etc.; (2) the Graduate Program in Aeronautics which supports graduate studies where the thesis research is performed, at least in part, at a NASA research center using NASA facilities; (3) the Post-Baccalaureate Program, which supports graduate study at the masters level including significant research experience at a NASA research center; (4) the Computational Fluid Dynamics (CFD) Training Program initiated in FY 1980 to support CFD training programs in selected universities; and, (5) the base level support for the Joint Institute for Advancement of Flight Sciences, and the George Washington University program at Langley Research Center.

The research supported under this activity will be conducted as a broad study of innovative ideas, such as theoretical mathematics, that underlie and cut across the spectrum of disciplinary activities, and thus contribute to long-term growth in aeronautical technology.

General Aviation and Commuter Research and Technology

The objective of the general aviation and commuter research and technology program has been to provide the technology base for achieving much needed improvements in general aviation aircraft safety, utility, and energy efficiency. Multidisciplinary in nature, the program encompasses aerodynamics (performance, stability, and control); materials and structures; propulsion and fuels; and, human factors.

The stall/spin program emphasis shifted to development of analytical techniques for predicting aircraft stall/spin characteristics and reliable design methods for achieving desired stall/spin characteristics in new aircraft. Drag reduction research emphasized natural laminar flow (NLF) airfoils suitable for general aviation. Instrumented wind tunnel and flight tests of several airfoil types demonstrated that the theoretically predicted extent of NLF could be approached closely with wing surface conditions achievable using modern manufacturing methods. Aircraft drag reductions of more than ten percent appear feasible through the eventual exploitation of NLF technology with attendant improvements in fuel economy. Propulsion research on low speed propellers and intermittent combustion engines continued. Flight tests confirmed that modifications previously demonstrated in the laboratory can achieve more than ten percent improvement in fuel consumption for certain types of existing spark-ignited reciprocating aircraft engines. Laboratory research on advanced fuel-efficient and lightweight general aviation engines, both rotary combustion and reciprocating types, proceeded with emphasis on stratified charge, multifuel combustion systems. In structures research, dynamic testing of load-limiting seats and fuselage structures proceeded with embodying the best features of previous research. A contract study of composite structural design and fabrication techniques best suited for light aircraft use was begun to help provide a basis for planning focused research. Human factors research emphasized improvements in single pilot instrument flight rule operations. A major activity in this area was the investigation of simple visual flight path control and computer-generated cockpit display concepts. Research on agricultural aerial applications was concluded with flight test verification of computer codes for predicting liquid and solid material distribution patterns in aircraft wakes.

In FY 1983, the essential elements of the program associated with generic research and technology will be pursued within the individual research and technology base discipline programs in propulsion, aerodynamics, materials and structures, and human factors.

Low Speed Research and Technology

The objectives of the low speed research and technology program are to provide technology bases in the areas of rotorcraft structures and dynamics, aerodynamics, flight dynamics and control, man-system integration, and wind tunnel and flight experiments support. Specific objectives include: (1) long-term evaluation of flight service of composite components; (2) reduction in vibration and loads; (3) prediction of external noise; (4) analysis of transonic flow, blade vortex interaction and wake flow; (5) development of handling qualities criteria; and, (6) development of a technical base of human information transfer in the unique helicopter cockpit environment. These efforts are complemented by portions of the systems technology program in rotorcraft.

During the past year, static and fatigue tests of the S-76 helicopter graphite and Kevlar components were completed. The design and fabrication of an OH-6 helicopter higher harmonic control system was completed in preparation for flight tests. A NASA Structural Analysis (NASTRAN) finite-element analysis design method was developed for helicopter airframes. Unsteady aerodynamic analyses were updated to include time-domain compressibility and viscous tip vortex flow. Acoustic prediction codes were extended by adding broadband and random loading capability. Fully transonic, three-dimensional analytical codes were transferred to industry and are now being extended to include tip vortex interaction. Work was initiated for small-scale tests of main rotor/tail rotor/fuselage interactions. In the flight dynamics area, an analysis of the YAH-64 advanced attack helicopter handling qualities in nap-of-the-Earth flight was completed together with studies of sidearm 4-axis control, excess power, and engine transients. Human factors research included the completion of initial instrument position control study and a flight study of pilot performance utilizing speech recognition automated equipment.

The long-term service evaluation of composites will continue with static tests of Bell 206L helicopter components removed from the field. Support of the Army all-composite aircraft program will include laboratory tests of fabrication techniques and materials use. The proof-of-concept flight tests of higher harmonic control on the OH-6 research helicopter (jointly funded by the Army) will be completed, thus demonstrating the feasibility of meeting "jet-smooth" ride vibration levels. A second set of model rotor tests will be conducted on tip shapes to validate reduced noise and load levels. Oscillatory airfoil tests will be used to validate a time-dependent boundary layer separation analysis of dynamic stall. This work will be evaluated for the second generation aeroelastically conformable rotor blade design that is the basis for the Army's integrated technology rotor program.

In the area of aeroelastic stability, a second series of full-scale wind tunnel tests of the bearingless main rotor will be conducted in the Ames Research Center full-scale facilities complex. A model test of individual blade control for flutter suppression will be completed. Several advanced hub designs will be completed.

Acoustic prediction methods will validate the broadband noise contributions using full-scale flight data from the AH-1G helicopter tests. Small-scale tests with the Army will examine noise scale effects and the problems of detectability. An acoustics specialists workshop will be held to define the remaining research tasks toward a "design-for-noise" capability.

A major effort in interactional aerodynamics will grow to include rotor wake flow effects, rotor/fuselage/tail rotor interference and related loads and noise levels. Of particular interest are the problems that arose in the Army's utility and attack helicopter development programs.

In the area of flight dynamics, math models will be refined to compare flight and simulation results in the high power/thrust conditions found in Army nap-of-the-Earth flight. The Army bailed, variable stability CH-47 helicopter will be upgraded and, in a joint simulation exercise with the Army, the four-axis pilot stick controller will be evaluated. Under human factors research, specific instrument and control positions will be assessed for pilot performance and workload. Work on defining and evaluating the processing of auditory information from synthesized speech will continue. Advanced control work on redundant actuator and multiprocessor control will be phased into support of the Army's advanced digital optical control system program. Instrument Flight Rules rotary-wing certification criteria work will continue.

Theoretical aerodynamics work will continue with a multiyear effort to include a rotor wake model with the three-dimensional transonic code. A fast optimization routine will be developed and installed at the helicopter companies. Off-blade pressure distributions will be developed for use in high speed noise calculations. Navier-Stokes solutions of two-dimensional, unsteady stall will be tried. Experimental testing in the Ames Research Center 2 x 2-foot transonic wind tunnel will be continued on a variety of airfoils including circulation control airfoils in a cooperative effort with the United States Navy. Analysis of blade-vortex interaction will continue with the modeling of noise effects.

High Speed Research and Technology

The objective of the high speed research and technology program is to generate technology advancements needed to establish and maintain technological superiority in high speed aircraft and missiles, including powered-lift aircraft with vertical or short takeoff and landing capabilities (V/STOL), supersonic cruise and maneuver aircraft with conventional or short takeoff and landing (C/STOL) characteristics and hypersonic cruise aircraft.

In the area of high speed powered lift research and technology, emphasis continues on analytical and experimental efforts to achieve improved lift/thrust performance and vehicle control for vertical/short takeoff and landing aircraft, particularly for shipboard operations. Configuration studies and supporting research are concentrated on new concepts of integrating aerodynamics and propulsion to achieve more competitive high speed characteristics with satisfactory low speed flight performance and handling qualities in poor weather conditions. In flight dynamics, extensive analysis, simulations, wind tunnel tests, and free-flight model tests are being performed on new fighter aircraft concepts, such as the three-surface configuration, to achieve improved high angle-of-attack and stall/spin flight characteristics. In the aerodynamics and propulsion intergration area, cooperative efforts with industry on high performance military supersonic airplane design concepts are being pursued in a combined analytical/experimental program. During the last year, the first hot engine altitude chamber tests of a two-dimensional convergent-divergent low-aspect-ratio exhaust nozzle were accomplished and the preliminary conceptual design of high-aspect-ratio exhaust nozzles was initiated.

High speed aircraft controls technology studies have been initiated to determine the best system architecture for highly integrated airframe and propulsion controls applicable to future high performance aircraft having very strong and significant airframe/propulsion interactions. These studies will also assess the applicability of advanced hardware elements and concepts to future intergrated control systems.

Following termination of the supersonic cruise research systems technology program, the high speed aircraft structures effort was directed at the analysis of flight test data for both the longitudinal and lateral dynamic response modes of the flexible body of the B–1 aircraft at supersonic speeds. In addition, the work in supersonic aerodynamics, configurations and integration included wind tunnel model tests of advanced high speed aircraft designs; simulation studies of handling qualities and advanced flight procedures for large high speed aircraft; construction of a supersonic variable diameter centerbody inlet; and advanced nozzle integration tests in the transonic speed regime. Work continued in hypersonic airbreathing vehicle research to evaluate turbojet/ramjet integration concepts including wind tunnel tests of hypersonic vehicle concepts of off-design conditions, and development of aerodynamic prediction and performance codes.

In FY 1983, the powered lift research and technology effort will concentrate on the development and verification of analytical prediction methods essential to the future development of efficient and effective military V/STOL aircraft. The results of extensive large- and small-scale wind tunnel model tests on the promising tilt-nacelle Navy configuration performed in FY 1981 and FY 1982 will be collated and correlated with theoretical predictions. Experimental activities will be extended to encompass the combination of the ejector thrust deflector and swept forward wing concepts potentially applicable to satisfying the performance requirements of V/STOL fighters.

The flight dynamics effort will emphasize three areas of fundamental concern to tactical military aircraft: basic analyses of nonlinear high angle-of-attack flight characteristics, stall/spin behavior, and improved high altitude, low speed combat maneuverability. Piloted simulation studies will be extended to investigate in more detail the best concepts for integrating thrust vectoring with aerodynamic controls and for utilizing thrust vectoring throughout the complete flight envelope. Wind tunnel tests will supply the static and dynamic data needed for the simulation studies.

In FY 1983, the aerodynamics and propulsion integration activities will concentrate on research for short-takeoff-and-landing, stealth, and supersonic persistence capability for future tactical military airplanes and advanced high speed concepts for future missiles. Supersonic aerodynamic analysis methods will be extended to include combined linear/nonlinear conical solutions and will be applied to promising unconventional configurations. Extensive nonaxisymmetric vectoring exhaust nozzle testing on afterburning engines in an altitude chamber and selected high speed wind tunnel testing of advanced fighter concepts will be performed to verify prediction methods and help establish a valid data base.

The high speed aircraft controls research effort in FY 1983 will transition from the current studies activities to initial experimental research in ground facilities to validate advanced integrated airframe/propulsion control system architecture concepts. Emphasis will continue on potential applications for future military aircraft concepts having strong airframe/propulsion dynamic coupling and will address key systems reliability factors.

High temperature structures technology will be directed to high temperature, low conductivity titanium structural/fabrication concepts applicable to high speed cruise aircraft configurations.

The area of supersonic aerodynamics, configurations, and integration will address advanced multibody configuration concepts for supersonic cruise and high speed fighters; initiation of tests on the variable diameter centerbody inlet; completion of tests and analysis of the nozzle-wing supersonic flow field interactions; continuation of the handling quality/advanced procedures simulation; and fabrication of a supersonic fan.

Hypersonic cruise aircraft research activities will continue to be directed at the complex vehicle/propulsion system integration problems; advanced inlet and nozzle concepts; and unconventional passively-cooled structural integration for advanced aircraft and missile application.

Propulsion technology will address the performance/integration problems of advanced variable cycle engines in high performance airplanes including future supersonic cruise and maneuver and supersonic VTOL fighter aircraft configurations.

In FY 1983, the interagency and industrial assistance and testing effort will use the technical expertise, computational facilities, wind tunnels, simulators and specialized test aircraft at all NASA aeronautics research centers to directly support Department of Defense agencies and the airplane/missile industry. This development and advanced research assistance program will respond directly to specific requests and will involve a wide range of military airplane and missile developments.

Support operations activities will concentrate on high speed wind tunnels. The transonic and supersonic wind tunnel operations in FY 1983 will generate extensive experimental data for a range of vehicle configurations and classes with emphasis on high performance military aircraft.

Transport Research and Technology

The objectives of the transport research and technology program have been to provide a broad base of safety oriented technology and to enhance the data base in transport propulsion-airframe integration. The safety research emphasized the understanding of aeronautical safety hazards and their consequences, and improving criteria for design of aircraft systems and operating techniques leading to reduction in accidents, loss of life and injuries, and loss of equipment. The safety research program had been organized into three major categories: aviation meterology, aviation operations safety technology, and aircraft systems operating efficiency improvement.

In meteorological research, significant progress continues to be made in characterizing lightning and turbulence associated with severe storms. A specially hardened and highly instrumented F-106 research airplane safely penetrated thunderstorms to obtain measurements of lightning and the production of gases, winds, and turbulence. The test results will provide a basis for establishing design and lightning protection criteria for advanced digital avionics systems and nonmetallic structures. This unique, high quality data is being provided to industry and the Federal Aviation Administration (FAA) for use in design and standards establishment, as well as aircraft operating procedures, and for the prediction and avoidance of severe storms. Research continues in the development of a computer code for the prediction of severe storms. In-flight remote sensing of hazardous clear air turbulence continues based on microwave radiometer technology. The expanded icing research and technology requirements were developed from a cross section of the aviation community and the FAA. Analytical methods were initiated for predicting ice accumulation and associated aerodynamic penalties. Ice protection systems for modern airfoils were evaluated using fluids, icephobics, and advanced pneumatic boots. In-flight icing research was initiated to correlate wind tunnel and analytical prediction research. Several cooperative icing research agreements were finalized with the Department of Defense and FAA. Flight research was initiated to measure the aircraft wing span-wise structural loadings due to atmospheric turbulence. An FAA, NASA, National Science Foundation (NSF) cooperative research program was initiated to accurately quantify real time hazards of low level wind shear and turbulence. The results of the cooperative meteorology hazards research will also be used in advanced pilot training simulators to reinforce pilot awareness and improve procedures.

Advances were made to increase occupant survivability in postcrash fires by breaking the fire chain through the use of safety fuel, antimisting kerosene, and fire resistant aircraft seat cushions, interior wall panels and fuselage windows. Advanced technology materials continue to be demonstrated in full-scale fuselage fire tests and evaluations of antimisting kerosene in jet engines using FAA, NASA and industry facilities.

The in-flight airframe operation measurement effort which utilizes digital data from widebody aircraft continues. It was expanded to cover ground operations to define the performance of landing gear system components during actual operating conditions. Advanced technology landing gear, antiskid brake systems, and tires will evolve from this knowledge.

In landing gear systems research, analytical tire modeling and a taxiing tire thermal study were verified. Research was initiated on tire and wheel failures and their consequences on aircraft control and loads transmitted to the landing gear. Based on initial successes of active control landing gear research to reduce structural loading and improve ride qualities, cooperative research was completed with the military to test this concept on fighter aircraft. The results of the brake dynamic studies were incorporated into antiskid braking simulations. Expansion began on the loads test track facility to match the aircraft speed and landing systems loads of current and future aircraft weights and speeds.

In FY 1983, reduced elements of the transport aircraft safety program applicable to generic research will be carried out under the materials and structures and the aircraft controls and guidance research and technology base programs.

Systems Technology Programs

FISCAL YEAR 1983 FUNDING LEVEL

Propulsion systems technology	$4,200,000
Low speed aircraft systems technology	38,300,000
High speed aircraft systems technology	24,700,000
Transport aircraft systems technology	8,100,000
Advanced propulsion systems technology	16,800,000
General reduction to low speed and high speed	−13,000,000
Total	79,100,000

Propulsion Systems Technology

The objective of the propulsion systems technology program has been to provide focused systems research to achieve improved performance, fuel efficiency, reliability and durability; fuel flexibility; and, reduced environmental impact for advanced propulsion systems applicable to a broad range of vehicle systems.

The helicopter transmission system technology effort is addressing key technology requirements to improve the life and reliability and reduce the size, weight, and noise of transmissions for military and commercial helicopters through the application of advanced concepts, analytical techniques, and other technology advances stemming from research and technology base efforts. Initial testing and analysis of the hybrid traction drive transmissions have been completed. Testing of an advanced technology conventional gear transmission is progressing.

Low Speed Aircraft Technology

The objective of the low speed aircraft systems technology program is to provide ground-based and flight research on integrated systems which hold promise for future civil and military rotorcraft and short takeoff and landing concepts. The program covers the broad technology areas of: configuration aerodynamics; propulsion; integrated flight systems, including controls and guidance; and, structural systems, including advanced materials applications, aeroelasticity, vibration and acoustics. The experimental ground-based and flight testing is closely coupled with collocated Army laboratory efforts and complements the research and technology base program activities. Specific objectives include: improvement of the rotocraft operational capability in instrument meteoroligical conditions; technology advancements for self-contained, low cost, low complexity guidance systems for all-weather operations to remote sites; validation of simulations and wind tunnel tests; and development of a wind tunnel data base in aeroacoustics, vibration, performance and rotor stability and determination of the initial feasibility of high risk rotor design approaches. Other objectives are the assessment and documentation of quiet propulsive lift concepts and the feasibility and merits of the tilt rotor concept, and the enhancement of propulsion system durability, reliability, and efficiency through advanced fabrication suited to rotorcraft applications.

During FY 1981, the low speed systems technology program accomplishments included a wide variety of activities. The quiet propulsive lift research effort included completion of downwash flow measurements on the quiet short-haul research aircraft (QSRA) and completion of extensive QSRA flight tests to determine the trade-off between take-off distance and payload made possible by the upper-surface-blowing lift augmentation capability which will have important application to improved transport aircraft. Rotorcraft systems technology research progress included completion of airborne radar simulation capability and flight test of automatic tracking and passive ground-link techniques for radar approaches to remote sites and flight tests of a highly instrumented AH-1G helicopter for simultaneous airloads and external noise measurements. Both of the rotor systems research aircraft (RSRA) configurations (helicopter and compound) are now operational, and flight research continues following the completion of the helicopter load measurement systems. Vertical drag was measured in hover and low speed forward flight for the first time using capability of the RSRA. Analysis and documentation of the bearingless main rotor, advancing blade concept and X-wing, full-scale, wind tunnel test data were completed. Small-scale tests of innovative rotor concepts were conducted to explore their feasibility. Two XV-15 tilt rotor research aircraft were successfully flown in proof-of-concept flights demonstrating safe flight envelopes at limited weight and center of gravity points. Hover noise flight tests were documented, and demonstration and pilot evaluations were continued including a tilt rotor flight demonstration at the 1981 Paris Air Show. Planning is progressing for the procurement of a modern Army 4-bladed rotor for flight test on the RSRA. A rotor and controller are being procured for higher harmonic control parametric testing at full-scale in the Ames Research Center full-scale facilities complex.

Preparations are underway for flight tests with the Army of a blade deicing boot to determine effects on rotor performance. Preliminary design of test-bed engine modifications to explore the technology options for a convertible engine concept was completed. A large Army transmission (XCH-62) was tested for a 50-hour period to provide the data base for improved spiral bevel gear analytical methods. A long-term study of helicopter internal noise diagnostics and control was initiated to look at the system aspects of noise generation and transmission. Preparations are underway to conduct a ground shake test to obtain vibration data on an Army CH-47 airframe for correlation with an analytical prediction method which was recently completed.

The rotorcraft operating systems advanced technology activity will continue with emphasis on all-weather rotorcraft capability for instrument flight in remote-site operation. Increased emphasis will be placed on support of the Federal Aviation Administration's helicopter operations research and development program with specific emphasis on instrument flight, icing, and noise technology and certification requirements.

Advanced rotor systems technology will continue with completion of flight tests of the Army/NASA RSRA with the present S-61 rotor. This will be followed by preparation for installation of an existing Army 4-bladed rotor. Calibration of the second RSRA aircraft will be completed. Analysis of higher harmonic control flight test results will be completed and compared with analytical prediction methods. Additional full-scale wind tunnel tests of the bearingless main rotor will be conducted for comparison with predicted performance and aeroelastic stability methods. Small-scale model tests will be conducted to explore the feasibility of incorporating free tips on rotor blades for improved performance and reduced noise.

Other advanced rotorcraft technology efforts will continue including full-scale rotor/fuselage interference tests, fabrication of composite tilt rotor blades for wind tunnel testing, and initiation of small-scale tests of advanced research rotor configurations in a joint effort with the Army. In the area of vibration, full-scale wind tunnel tests of higher harmonic control concepts will be conducted to establish a parametric data base for the design of future systems. Dynamic calibration of the RSRA load measurement systems will be initiated to provide a capability to measure vibratory hub loads in addition to the static loads capability. Documentation of the deicing boot installation performance will be completed. Human factors research specific to rotorcraft will be conducted addressing the influence of display systems on military pilot workload. An evaluation will be conducted of the needs and performance of zero-zero meteorological conditions operation of externally slung cargo loads in a simulation effort. An effort to assess the trade-offs of a blade radar installation for remote-site, all-weather operations will be initiated.

The development and validation of the finite-element analytical methodology for large spiral bevel gears will be completed. Convertible engine test hardware modifications will be fabricated and assembled, and steady-state testing will be initiated.

High Speed Aircraft Systems Technology

The objective of the high speed aircraft systems technology program is to generate validated engineering and design data applicable to the development of advanced high performance, high speed aircraft for military and civil applications. The program objective is accomplished by analyses, ground-based simulations, and wind tunnel experimental research and flight research tests.

During the past year, the high performance flight research program effort included the successful validation of a NASA-conceived aileron-to-rudder interconnect control system on an F-14 aircraft as part of a joint NASA/Navy program to improve high angle-of-attack flight characteristics. Major progress was made on two elements of the joint NASA/Air Force advanced fighter technology integration project involving integrated fire/flight controls in an F-16 aircraft and a mission adaptive wing on a F-111 aircraft.

Both highly maneuverable aircraft technology vehicles were successfully flown during the past year. Flight test data have been acquired in areas of stability and controls, structures, flutter, and propulsion. In FY 1982, the vehicles will be flown to acquire flight environmental experiment data on the aeroelastically tailored graphite composite wing/canard structure at design conditions. Both vehicles will be used to complete the flight assessment of the aerodynamic performance and the stability and control of the closely coupled wing/canard design configuration. Tests will include flight maneuvers at different altitudes and speeds with reduced and negative static stability to assess the vehicle performance.

The FY 1983 funding level reflects an increased emphasis on high performance flight research in support of defense-oriented research and development. The high performance flight research activity in FY 1983 will involve a variety of high performance aircraft to investigate advanced concepts. Two joint NASA/Air Force projects will enter the flight test phase during this period. The advanced fighter technology integration F-111 aircraft will investigate the performance of the variable camber mission adaptive wing. Advanced fighter technology integration/F-16 aircraft will evaluate an advanced digital flight control system and an advanced fire control system. Both advanced fighter technology integration flight test activities will be performed by the joint NASA/Air Force test teams.

In FY 1983, the joint NASA/Defense Advanced Research Projects Agency X-29A forward swept wing flight demonstration program will be undergoing extensive wind tunnel tests, computational analysis, and ground tests in preparation for the flight test in FY 1984. In FY 1983, the highly maneuverable aircraft technology flight test program will be completed and data will be reduced, analyzed, and reported, at which time the program is scheduled for completion.

In FY 1983 flight research operations support will include chase operations, airspeed calibration pacer flights, remotely piloted research vehicle air drops, and crew flight-readiness operations.

Commencing with FY 1983, the turbine engine hot section program will be transfered from materials and structures systems technology to high speed systems technology. During FY 1983, the emphasis of the turbine engine hot section activity will be on defining the turbine environment through the conduct of "benchmark" component simulation tests and the development of associated instrumentation. In these tests, relatively simple hardware elements containing stress concentrations will be subjected to high temperature, low cycle, creep fatigue conditions. Simultaneously, analytical solutions for stresses and strains of the stress discontinuity will be obtained from available three-dimensional, finite-element, elastoplastic computer programs. Direct measurements of the local strains in the high temperature testing activity will provide the desired check on the ability of the structural analysis to accurately calculate the stress/strain conditions and provide insight for future improvements that may be needed. In addition to the "benchmark" tests, a broad range of component simulation tests will be designed and conducted for defining static and cyclic thermal and mechanical loadings, the materials and structural responses, as well as failure locations, modes, and lifetimes for combustor liners, turbine vanes, blades, and disks, gas path seals, and static structures. These simulations will provide documentation test conditions and durability data for use in model formulation and subsequent predictive methods evaluation. Research on high temperature materials will emphasize the physical effects of alloying constituents on material behavior.

High speed system studies will address military applications of supersonic cruise technology. The ongoing studies of the potential for supersonic persistence of tactical military aircraft using advanced technology will be extended to assess overall effectiveness of the systems for various tactical and strategic mission scenarios.

Transport Aircraft Systems Technology

The objective of the transport aircraft systems technology program has been to develop and demonstrate, in a realistic environment, advanced subsonic transport aircraft technology for enhancing aircraft energy efficiency and providing operational compatibility with the future National Airspace System.

The laminar flow control program has entered the fabrication phase to provide verification of promising structural concepts, operational experience with leading edge systems, and suitability of advanced airfoils for laminar flow control. New materials methodology and manufacturing techniques are being utilized to develop and demonstrate a practical, reliable, maintainable laminar flow control system for future transport aircraft and to convince the air transport industry that laminar flow control technology is ready for exploitation in 1990's transports for significant fuel economy.

The energy efficient transport activity has included the evaluation and development of advanced aerodynamics, propulsion/airframe integration, and active controls technology for both nearterm and future application to civil and military transport aircraft.

In FY 1982, in-house activities are focused on active control system definition and component development. Fabrication and assembly of the high-aspect-ratio aeroelastic research wing will continue through FY 1982. Evaluation of engineering models of fault-tolerant computer concepts will continue in FY 1982. Also continuing in FY 1982 is in-house research focused on the integration of engine nacelle configurations (emerging from the advanced engine programs) with advanced high-aspect-ratio supercritical wings to obtain the maximum benefit from these technologies. Major contract activities with Boeing, Douglas, and Lockheed have involved the evaluation of selected near-term concepts for increasing fuel efficiency. In FY 1982, emphasis will continue on the integrated application of active controls and relaxed static stability to the design of energy efficient transports.

Advanced composite airframe components can reduce weight by 20–25 percent and can reduce manufacturing costs. The composite primary aircraft structures efforts are developing composites technology to permit future transport aircraft to safely and economically attain predicted weight and cost benefits in secondary and medium primary structures. The approach has been to design, fabricate, and certficate six representative composite components. All three secondary structure components have been certificated by the Federal Aviation Administration and, in FY 1982, twenty-two sets of these components will be in flight service. These programs were a major influence on the Boeing 767 transport aircraft now flying with over 3,000 pounds of composite secondary structures. Certification of the Boeing 737 composite horizontal stabilizer first flight in September 1981 has been delayed until April 1982 to resolve questions on evnironmental effects, birdstrike problems, and an early failure in damage tolerance tests. The Lockheed L–1011 composite vertical fin, which failed at 98 percent of ultimate load in ground tests, will be repaired and testing continued in FY 1982.

The Douglas DC–10 vertical stabilizer has just begun structural tests, and a flight checkout is planned for March 1982. Key technology programs for fuel containment, critical joints, durability, and damage tolerance for large primary structures are continuing in FY 1982 with design work and small element tests.

The composite primary aircraft structures program will complete all ground tests to meet certification requirements in FY 1982 on medium primary structures. The 737 horizontal and the DC–10 vertical stabilizers will begin flight service evaluation. The L–1011 fin will complete certification tests in FY 1982. Programs focused on critical design technology will be phased down during FY 1982.

The terminal configured vehicle program is an intensive research and technology activity to define functional requirements and performance criteria for flight systems and displays of the future with which the pilot can safely and effectively integrate with an advanced air traffic system environment. Research is being conducted in performing more efficient flight with respect to fuel, airspace, and time; increasing traffic flow capacity; improving the operational capability in adverse weather; and reducing noise impact on the ground.

Advanced Propulsion Systems Technology

The objectives of the advanced propulsion systems technology program are to achieve improved performance and lower fuel consumption and to reduce noise and emissions from future aircraft engines through the integration of improved propulsion components.

The component development and integration phase of the energy efficient engine program continues. Full-scale component rig testing is nearing completion. Tests have been completed on the exhaust gas mixers and the combustor sector rigs at both contractors: the 23:1 pressure ratio compressor, the low pressure turbine and the fan at General Electric; and the 14:1 pressure ratio compressor at Pratt & Whitney. The performance demonstrated in each of the component tests has met or exceeded pretest goals, indicating the high probability of achieving the overall program goals. In FY 1982, the remaining component tests will be completed at both contractors, and the gas generator core test initiated at General Electric.

The advanced turboprop program continues to hold promise of 15–20 percent fuel savings at Mach 0.7–0.8 cruise speed. Initial subscale propeller (prop-fan) model tests have verified potential efficiency of 80 percent at Mach 0.8. Measurements of noise generation and attenuation have confirmed analytical predictions in small-scale experiments. Installation aerodynamics wind tunnel investigations are underway, exploring the drag reduction potential of wing and nacelle contouring. Design studies of large-scale prop-fans, inlets and turboshaft engines are underway. Studies of testbed aircraft and drive-engine options will be completed in FY 1982.

10. SPACE RESEARCH AND TECHNOLOGY, $128,000,000

FISCAL YEAR 1983 FUNDING LEVEL

Research and technology base	$120,600,000
Systems technology programs	4,400,000
Standards and practices	3,000,000
Total space research and technology	128,000,000

The objective of the Space Research and Technology program is to provide the technology base upon which all future national space activities depend. This advanced technology has direct applications to both current and future space missions and, in large part, provides technology options which will enable missions that will not otherwise be possible.

The fiscal year 1983 program continues to stress those technology areas judged to be most critical by external advisory groups, by inhouse program assessment, and by the future users of the technology. Emphasis will be placed on advancements in disciplinary technologies required for the enhancement of planned missions and the enabling of future missions which are beyond current capabilities.

In fiscal year 1983, activities will focus on maintaining a strong research and technology base in the disciplinary areas of aerothermodynamics, chemical propulsion, materials and structures, electronics and automation, and space power and electric propulsion. These are the only NASA advanced research and technology programs designed to support and extend these critical aerospace disciplines. Activities in informaiton, spacecraft, and transportation systems research and technology are designed to study the interrelationships of discipline technology from an integrated systems point of view, and are critical to the successful transition of technology from the laboratory to useful application. In addition, systems-levels studies conducted within the reserch and technology base will continue to focus the discipline and system research and technology activities in directions which will lead to maximum benefits from available resources. Finally, systems technology programs involving the extension of ground-based research and technology activities to space using Shuttle, Spacelab, and free-flying vehicles will be continued. During fiscal year 1983, a number of space technology experiments will be performed aboard the Shuttle/Spacelab.

RESEARCH AND TECHNOLOGY BASE

FISCAL YEAR 1983 FUNDING LEVEL

Aerothermodynamics research and technology	$8,800,000
Chemical propulsion research and technology	19,500,000
Materials and structures research and technology	15,100,000
Electronics and automation research and technology	9,500,000
Space power and electric propulsion research and technology	21,000,000
Multidisciplinary research and technology	3,500,000
Information systems research and technology	24,000,000
Spacecraft systems research and technology	10,400,000
Transportation systems research and technology	8,800,000
Total research and technology base	120,600,000

Aerothermodynamics Research and Technology

The objective of this effort is to expand the understanding of the aerothermodynamics, gas dynamics, and flight mechanics associated with atmospheric entry and atmospheric maneuvers of aerospace vehicles designed for Earth orbital and planetary missions. Knowledge, developed through both analytical and experimental investigations of phenomena is the viscous to noncontinuum flow regimes, is applied to the improvement of the safety, economy, reliability, and efficiency of such vehicles. The experimental investigations make maximum use of the Shuttle, which provides a unique opportunity both on the orbiter and through the orbiter experiments, to perform aerothemodynamic research in the true reentry environment.

In the area of vehicle aerothermodynamics, the technology base for potential configuration concepts from single-stage to orbit to orbital transfer vehicles is being expanded by experimental and analytical investigations of aerodynamics performance and flow field phenomena, including real-gas effects, viscous interactions, heat transfer, etc. Technology assessment studies have indicated that the payload capability of reusable transfer vehicles to geosynchronous orbit can be substantially increased by employing the technique of aero-assisted, rather than propulsive, maneuvering to return to low Earth orbit. Investigations of rarefied flows aid in characterizing the interaction of the flow field phenomena with aero-assisted transfer vehicle concepts.

The focus of entry research is on the development of computational and experimental techniques for analysis and prediction of the fundamental thermodynamic and transport properties of aerothermodynamic environments characteristic of various planetary atmospheres, including Earth, and the interaction of those atmospheres with the vehicle materials and configuration. Aerobraking, which is economically advantageous for some entries, may operate completely in the noncontinuum flow regime, requiring statistical treatment of molecular collision processes at rarefied flow conditions. A direct computer simulation technique is being used to analyze these phenomena and characterize the aerothermodynamic environments.

In the flight data analysis effort, Shuttle orbiter experiments, such as the aerodynamic coefficient identification package, are being conducted on each flight; additional experiments, such as Shuttle infrared leeside temperature sensing and Shuttle upper atmospheric mass spectrometer, will be retrofitted to the current orbiter and flown on STS-9. These experiments provide research-quality data for use in evaluating and improving theoretical and ground-based experimental methods, as well as an increased data base for improving future vehicle designs.

In the area of space vehicle aerothermodynamics and configurations, efforts will continue in improving vehicle performance and reliability and reducing costs for a variety of potential missions. In FY 1983, continued emphasis will be placed on development and verification of theory, advanced computational methods, and computer codes for predicting vehicle flow fields and performance development of improved ground-based experimental techniques, instrumentation and simulation capability, provision of advanced vehicle design integration capability, and development of a data base from ground facility and flight investigations for support of future vehicle design.

The entry effort provides the base for characterization of the fundamental aerothermodynamic environments of vehicles entering or re-entering planetary atmospheres, including Earth's atmosphere. This technology base is used in the design, development, and verification of various potential configurations, and provides the flight mechanics data in support of atmospheric reconstruction experiments. In FY 1983, theoretical and experimental efforts will be pursued in the areas of shock-layer radiation, ablation product radiation and absorption, lightly-blown shock-layers, configuration flight mechanics, and mass loss and shape change. In addition, studies of the aerothermodynamics and aerobraking vehicle concepts will be further developed, with emphasis and analytical investigations of rarefied and transitional gas flows. These studies will be pursued to develop a data base to be used to minimize Earth orbital and planetary mission costs, to maximize the scientific returns, and to insure a high probability of mission success.

The flight data analysis effort will use the orbiter experiment flight data to study phenomena, which cannot be simulated in ground facilities, to develop and refine techniques for extrapolating ground facility results to flight conditions, to evaluate and resolve anomalous ground-flight results, and to verify analytical and computational prediction techniques. In FY 1983, development of analytical techniques will continue in preparation for analysis of subsequent orbiter and orbiter experiment flight data.

Chemical Propulsion Research and Technology

The objective of the chemical propulsion research and technology program is to develop technology to improve the life, performance, versatility, and reliability of chemical rocket propulsion systems for future space transportation and spacecraft systems. The program involves technology for reusable propulsion for lower cost operations; high performance, variable thrust, and low thrust propulsion for more versatile operations; autonomous propulsion for higher reliability; and, efficient, long-life position control and station keeping propulsion for large space systems.

In FY 1982, work on advance high pressure, oxygen-hydrogen propulsion is being expanded to increase the emphasis on technology advances that will allow the future upgrading of the life and performance of large, high performance propulsion systems including the Space Shuttle main engine. Technology barriers have been identified and programs initiated in appropriate areas. Work on advanced orbital transfer propulsion has been directed toward high performance, variable thrust engines which offer greater versatility in operating between low Earth orbit and geosynchronous orbit. Conceptual design studies were initiated to evaluate feasibility and to identify critical technologies. Significant technical activities in FY 1982 include demonstrating regenerative cooling of high pressure rocket combustors using liquid oxygen as the coolant as opposed to the currently used hydrogen or hydrocarbon fuel, and experimentally determining heat transfer rates generated by highly efficient, high pressure oxygen-hydrocarbon combustors. In addition, small hybrid bearings which had previously demonstrated long life under steady-state operating conditions in liquid hydrogen, are being successfully operated over a wide range of simulated start/stop transients. Finally, the higher performance of solid propellant formulations derived by blending high energy oxidizers is being demonstrated in experimental motor firings.

An expanded effort in advanced high pressure, oxygen-hydrogen engines is directed towards developing a better understanding of component operating environments and, through analysis and experimentation, establishing the capability of designing for long life and repeated use. Improved modeling in the areas of bearing and seal design, rotor dynamics, structural dynamics, combustion, ignition, and fluid and gas dynamics will enhance future design capability for critical life-limiting components. Advanced nonintrusive sensor designs will be explored that could provide in-place engine diagnostic and automated inspections and checkout capability. A comprehensive effort in materials development and evaluation, as well as advanced fabrication and manufacturing techniques, support this technology area.

Research and technology for reusable, high performance oxygen-hydrocarbon propulsion will continue to focus on fundamental work in the areas of combustion, stability, heat transfer and cooling for both primary and auxiliary propulsion systems. Experimental research will be used to upgrade our analytical modeling capability to much higher combustion pressures and provide the basis for optimizing engine designs for performance, life, reliability, and maintainability.

Work on orbital transfer propulsion will encompass critical component technology for variable thrust engines identified in ongoing conceptual design studies. Highly efficient turbomachinery and combustor operation over a very wide range of flow conditions are examples of technologies that need attention. In low thrust propulsion, efforts will continue toward characterizing small combustor performance, cooling and life, and in demonstrating efficient hydrodynamic operation of very small pumps. This technology will provide the basis for propulsion system selection for a broad range of orbital transfer missions.

Autonomous propulsion research and technology will continue to focus on sensors and sensing techniques that will be capable of detecting off-design operation and incipient failures. This information will be relayed to an engine controller that, in turn, will be capable of taking instantaneous corrective actions to maintain acceptable system performance and operations actions which would be impossible to take from the ground due to communication lag times.

Earth-orbiting large space systems will require onboard propulsion systems capable of maintaining precise position control as well as performing other functions such as drag makeup and stationkeeping. Studies are being conducted to identify candidate chemical propulsion systems for this application and critical technologies that need to be addressed. Research and technology will be conducted in FY 1983 in the identified critical areas.

Materials and Structures Research and Technology

This activity will develop the technology in advanced materials and structures for improving the performance, efficiency, durability and economy required for large area space structures for antennas and platforms, advanced space power generation, advanced space transportation systems, orbiting spacecraft, planetary probes, and payloads. Areas of emphasis include: (1) basic understanding of material science, including advanced metallics and intermetallics, long duration environmental effects of space, tribology, computational chemistry and surface physics, and bearings, lubricants, and seals technology; (2) development of composites, including both polymeric and metal matrices and the identification of environmental effects and damage mechanisms; (3) development of metallic and nonmetallic thermal protection systems; (4) definition of loads, dynamics and aeroelasticity of aerospace vehicles, payloads and spacecraft systems; and, (5) development of advanced structural concepts, integrated analysis, and synthesis techniques for design and qualification procedures involved in new systems with operational requirements well beyond the current state of technology.

A major research effort is being directed at determining the durability of polymeric materials in space, including structural composites, thermal control coatings, films, adhesives, and seals. The current emphasis is on identification of damage mechanisms and the development of methodology for accelerated tests to be able to predict long-term performance. Basic research in the fundamentals of tribology (friction and wear) of bearing systems and long-life space environment lubricants and seals continues to provide the technology for advances for future space transportation systems. Research on new ceramic fibers and coatings for advanced thermal protection remains a major thrust in this space activity. A ceramic tile exhibiting improved toughness and higher temperature characteristics has been demonstrated. The new fibrous refractory composite insulation developed in this program will be used on the next Shuttle orbiter, as well as a lightweight blanket-type insulation with greater durability than the existing system. In FY 1982, the instrumentation on STS-2 obtained detailed temperature distributions over a tile surface and the gaps between tiles. The measured data will be used to validate new thermal analysis methods under development. A new, more efficient algorithm for nonlinear analysis and synthesis for dynamic and thermal response was derived and verified against existing solutions. Research on stability and control, integrated thermal-structural analysis, and structural design optimization are continuing for advanced space transportation systems, payloads, large space structures, and spacecraft. Initial analysis methods for damping of space structures were verified by test in FY 1981. Erectable and deployable platform configuration concepts have been developed, and a ground test program to verify deployment dynamics and assembly techniques is in progress.

Basic research activities in FY 1983 will include pulsed radiolysis and determination of reaction rate kinetics to develop a radiation interaction model and investigation of optical reflectance and dielectric property changes as a consequence of radiation damage to chemical structures. Increased attention will be focused on identifying/developing structural materials that fulfill dimensional stability requirements of large space antennas and space stations. Aluminum matnix composites will be evaluated for feasibility as a lightweight, thermal, conductive, structural material for spacecraft. Enhanced properties, made possible with new fibers such as aluminum, silicon carbide, and graphite, will also be explored. Stable high temperature liquid and solid lubricants will be studied. Studies will be accelerated to examine the characteristics of intermetallic aluminides for applications such as advanced turbopumps for the Shuttle main engine. Although such aluminides are presently very brittle materials, research is directed toward solutions to that problem to allow significant performance improvements. Thermal protection concepts and materials will continue to be evaluated for the protection of reentry vehicles. In addition to ongoing work in advanced metallic and ceramic materials, this activity will be expanded to include advanced carbon-carbon composites. A better understanding of fundamental material surface behavior through the application of computational chemistry will continue to be a thrust in the program.

In FY 1983, research on truss structural concepts for deployable and erectable space systems and the indentification of design and qualification procedures required to meet possible future mission requirements will be emphasized. Simultaneous and sequential deployment concepts will be evaluated for potential application to platform configurations. In the area of integrated analysis and synthesis methods, emphasis will be on improved thermostructural modeling and analysis methods to include thermal radiation and convection effects on structural response.

Research will continue on: (1) nonlinear behavior due to large deformations and nonisotropic composite material application; (2) fatigue life of advanced metallic and composite materials; (3) structural controls; (4) dynamic interactions; and, (5) integrated thermal-structural analysis.

Payload analysis methods will focus on the adaptation of predictive methods to include coupled Shuttle loads and vibroacoustic response. The development of analyses and concepts for control of structural dynamic modes of space systems will emphasize methods to identify vibration modes and active damping control to reduce associated adverse effects.

The high temperature structures effort will continue research on: (1) metallic and advanced carbon-carbon structures for Earth entry vehicles capable of withstanding temperatures of 1500° F or more; (2) metallic multiwall thermal protection systems; and, (3) validated thermal stress prediction methods.

Electronics and Automation Research and Technology

The electronics and automation program consists of three discipline areas: electronics, automation, and guidance and controls. The objective of the electronics discipline is to advance the technology employ electronic sensing, detecting, and data processing systems. Areas of emphasis in this discipline include quantum electronics (laser research), signal detection and processing, and solid state research. Advances have been made in perfecting a tunable visible/ultraviolet laser which would be capable of ranging and detecting hydroxyl ions, nitrous oxide, ozone, and sulfur dioxide in the troposphere from an airborne platform for active remote sensing, the latter species being an important constituent of global acid rain. The concept of a fourier electronic transform device has been validated and efforts are underway to implement this technology in silicon for eventual use as a smart star tracker and on-a-chip image comparator. The microscopic properties of the silicon-silicon dioxide interface, an integral part of integrated electronic circuits, and its role in the space radiation degradation of electronic components is being unraveled. The physics and chemistry of this interface should eventually point to a method to rectify, by fabrication, the radiation susceptibility of these electronic devices.

The objective of the automation activity is to provide the theoretical and technological base needed to increase the productivity and effectiveness of humans, spacecraft, space operations, and facilities. The program is focused on automation technology for: (1) raising the level of autonomy of spacecraft; (2) performing effective in-orbit satellite servicing; (3) improving ground-based mission operations; and, (4) decreasing the overall cost of space transportation. This is accomplished through basic research and adaptation of non-aerospace automation technology to space oriented problems. Basic theories of automated problem solving are being developed to the stage that they can treat realistic space situations. Techniques for automatic experiment sequence generation were recently demonstrated which could be utilized in the Galileo mission in place of the manual logic that was utilized in earlier missions such as Voyager. These and similar techniques are being developed to manage spacecraft subsystems and provide automated fault diagnosis and isolation. A robotics research capability is being built up to provide technology for satellite servicing, and ultimately, for space assembly and construction. This part of the program is currently addressing supervisory control.

The thrust of future spacecraft is toward larger, loosely coupled structural systems which may be highly flexible because of the cost of delivering mass to orbit. Such spacecraft present formidable and as yet unsolved problems in control system design and advanced components. One objective of the space controls program is to develop the design concepts and techniques required to enable precise pointing and control of future spacecraft including space platforms, large antennas, and advanced space transportation systems. Related developments involve innovative guidance and control system components required for higher performance, longer life, and lower life cycle cost. Emphasis continues in distributed control concepts for active shape and vibration control, advanced modeling techniques for control system design, adaptive/learning system development to increase performance and fault tolerance, and high performance and long life control sensors such as the fiber optics gyro and the three dimensional optical sensor.

The electronics program will continue to perform research in laser technology concepts, models, and components in order to provide significant advances in the parameters necessary for passive and active remote sensing and optical communication. Emphasis will be on new data processing techniques employing optical and integrated optical technology that will enable new computational capabilities for the control of large space structures from real-time image recognition. Research into new devices grown by a technique called molecular beam epitaxy will enable new solid state devices that will extend detection capability with real-time processing capability.

During fiscal year 1983, the automation effort will be expanded to include those aspects of machine intelligence and robotics needed to increase autonomy of space systems. In particular, automatic sequence generation for orbital missions will be expanded and a systems architecture formulated for autonomous spacecraft and telerobots. Increased emphasis in computer science research and technology will address NASA's unique and broadly based needs in computer technology.

In fiscal year 1983, the controls program will continue development of advanced concepts and techniques required for effective control of flexible space structures. Simulations and experimental investigations will be carried out on decoupling control concepts and adaptive/learning techniques, and extended to applications of these approaches to lightweight, space-like structures. Techniques will be studied and compared for the design of effective control systems for large, highly flexible space structures including multiobjective insensitive designs and reduced order control models. Development will continue on a continuum model for a parabolic dish antenna with a boom support feed. Extensive studies will be conducted and a government, university, and industrywide semilar held on applications to distribute parameter system theory to large space system control. Continued development of analytical techniques for onboard model error estimation will lead to adaptive controller designs. In the advanced component area demonstrations will begin on a version of an all-waveguide, integrated optics, fiber-optic gyro. An advanced three-dimensional sensor concept for determination of shape and vibration motion of large space structures will be carried to a preliminary design. Increased emphasis will be placed on advanced space transportation system guidance and control development during fiscal year 1983 directed toward greater performance capabilities to reduce uncertainties and associated costs.

Space Power and Electric Propulsion Research and Technology

The objective of this research and technology program is to support, enhance, and enable current and future activities in the exploration and exploitation of space. The thrust areas are carefully selected to make the power subsystem more efficient, usable, and affordable in view of mission needs and to preserve and enhance a unique national capability in electric propulsion.

Significant progress has been made toward the development of a breadboard demonstration of a fuel cell/electrolysis cell energy storage system. A major thrust toward developing advanced, high capacity nickel-hydrogen batteries was started. Both of these technologies are designed to enable high power level missions in space. In the area of photovoltaics, researchers identified the failure mechanisms leading to the loss of power occurring in solar cells under deep space (low temperature, low intensity) conditions. The first gaseous solar pumped laser was demonstrated in the advanced energetics program. To provide an alternative source of high power (>100 kW) and enable operations independent of sunlight, critical technologies related to a future, nuclear reactor based power subsystem have been identified.

The ion thruster technology program was focused on the development of inert gas thrusters for on-orbit propulsion of large space structures and space stations. An effort to develop the high voltage, high power components and circuits that will be required for future low Earth applications will continue.

Major emphasis will be placed on evaluating and advancing the development of the fuel cell/electrolysis cell energy storage system. Efforts will continue toward development of safe, long-life, high energy density lithium batteries. Nuclear reactor power system technology will be enhanced by performing critical experiments to aid evolution of practical design options. Activities will continue in photovoltaics to improve conversion efficiency, reduce mass, increase operating life and reduce the cost of photovoltaic converters and arrays. Research and technology will focus on thin, high efficiency cells, solar array welding, and advanced blankets. The assessment of advanced concepts for space energy generation, conversion, storage, and distribution will continue under advanced energetics with emphasis on research on solar-pumped lasers and laser receivers.

In the area of electric propulsion, emphasis will be on increasing the thrust-to-power ratio of Mercury thrusters by a factor of two. Additional emphasis will be placed on the development of inert gas thrusters, specifically reducing the energy required to create ions and increase propellant utilization efficiency.

In the area of power management, work will continue to be directed toward high voltage, high power electrical components, power transfer devices, and analytical modeling of space plasma interactions. A thermal management program will focus on developing technologies related to constructable radiator systems and to thermal transfer technology.

Multidisciplinary Research

The objective of the multidisciplinary research program is to conduct long-range, basic research in the engineering and physical sciences focusing on high risk areas with revolutionary high potential payoff for space application and technology. A majority of the research is conducted at universities through either the Fund for Independent Research (FIR) or the Physics and Chemistry Experiments in Space (PACE) programs. The former program supports research across a broad spectrum of basic sciences and engineering fields such as atomic and molecular theory and spectroscopy, solid state and condensed matter physics, quantum electronics, theoretical and experimental fluid mechanics and dynamics, materials and structural sciences, and mathematics. The latter program supports studies for the design of basic science and engineering experiments that will resolve fundamental scientific questions and discover new phenomena in which conditions of zero or near zero gravity are prerequisite. Some of the studies include experiments on the vibrational modes or liquids, behavior of quantum fluids, combustion, and the dynamics of convection.

The research supported under this activity, such as theorectical mathematics, will be maintained as a broad study of innovative ideas that underlie and cut across the established disciplinary structure and thus contribute to long-term growth in space technology.

Information Systems Research and Technology

The objectives of the information systems research and technology are to provide advanced sensor, data and communications technology options that will enable and enhance future Earth resources, environmental observations, and space science missions, as well as a thrust toward the future of permanent occupancy in space. These technology options focus on efficient and timely acquisition, processing, reduction, and distribution of space acquired information.

Linear and area detector array technology covering wavelength ranges from 2 to 100 micrometers for infrared images of terrestrial, planetary, and astronomy scenes are being developed. A 2 by 64-foot linear charge injection device array was coupled with the 120-inch telescope at Lick Observatory for the first successful demonstration of infrared imaging with this resolution for astronomy. Quasioptical submillimeter receiver systems, with frequency capabilities in the 0.5 to 20 terahertz (THz) range and active laser senors, are being developed for detection of the relative abundance of atmospheric trace gases. The 600 gigahertz (GHz) microwave radiometer was flown on a NASA aircraft mission to demonstrate its ability to measure atmospheric gases in the stratosphere. Cooling systems technology is being advanced in the area of long mission life refrigerators, dewars and ultralow systems for cooling sensors and experiments in space. The first noncontacting bearing mechanical cooler has been fabricated and tested meeting its design goals of 70° K with a 5-watt cooling load.

In satellite communications techology, the 20 GHz traveling wave tube (TWT) development effort has produced an experimental model TWT employing dispenser cathode and multistage depressed collector technologies. In the 30/20 GHz solid state component area, a program was initiated to develop monolithic transmit/receive modules for a monolithic phased array antenna. A configuration study for the monolithic transmit array antenna will be completed in fiscal year 1982.

The narrowband communications program completed a conceptual design of a large multibeam satellite antenna for land mobile satellite service. Analysis and tradeoff studies in conjunction with the antenna aperture and reflector were also completed. Development of power amplifiers, diplexers, and the antenna beam forming network were initiated.

Advances in communications technology to support NASA missions included the development of a spacecraft flight Ku-band modulator/exciter. This device is capable of transmitting data at rates as high as 2.5 gigabits per second and represents the state-of-the-art in microwave integrated circuit design. A breadboard scaled version of this technology was demonstrated at 60 GHz, a candiate intersatellite frequency. A low noise, solid state receiver development produced performance beyond the state-of-the-art at both Ku and Ka bands. This uncooled receiver will be targeted toward future NASA data communication applications. In the development of high efficiency, solid state x-band technology for deep space missions a high efficiency 10-watt transmitter was demonstrated.

In support of efficient data processing concepts, onboard data processing capability is being advanced. Technology was demonstrated to enable onboard radiometric correction and computation of geometric distortion coefficients of satellite image data. Also, a working engineering model of an onboard automated attitude determination system was completed. This technology will allow future missions to integrate auxiliary information with senor data packets onboard.

The feature identification and location experiment was part of OSTA-1 and was a successful experiment. Sufficient experimental data was gathered to demonstrate onboard feature classification. The superfluid helium experiment has completed system integration and is targeted to evaluate the properties of superfluid helium in low gravity aboard the Spacelab-2 mission.

During fiscal year 1983, the two-channel tunable diode laser heterodyne spectrometer will be flown to several NASA CV-990 flights to demonstrate high resolution measurements of atmospheric constituent solar absorption spectra. The initial target gases are ozone and nitrous oxide. The six-channel airborne subnanosecond laser ranging system for measuring regional crustal deformation will be test flown. A state-of-the-art advancement in quasi-optical components for submillimeter wavelength regions will enable the measurement of hydroxyl free radical and atomic oxygen during the flight test of the 1.8-THz microwave radiometer. In the spring and summer of 1983, the L-band multibeam push broom microwave radiometer will be field tested as a part of the AgRISTARS program. During the growing season of 1983 and two subsequent years, the brightness temperature will be processed to give day-by-day data on field soil moisture content. During fiscal year 1983, the mechanical cooler will continue in its life test. New solid state refrigeration concepts will be investigated. These systems will be used to evaluate the optical properties of typical infrared optical elements at cryogenic temperatures.

In fiscal year 1983, OAST will continue the development of the multistage depressed collector utilizing pyrolytic graphite a low secondary electron yield material. The pyrolytic graphite multistage depressed collector will be installed in the experimental model (TWT) and tested. Initial delivery of transmit and receive monolithic modules will be made. Design and fabrication of 20 GHz monolithic array antenna will be completed. A technology activity to apply tunneladder circuit technology to low cost 30 GHz TWT transmitters will be initiated this fiscal year.

Aperture tradeoff studies and feed element development for the land mobile satellite service will be concluded. Breadboards of the beams forming network and power amplifier will be completed. Integration of the beams forming network into a full-scale feed structure will begin, as well as testing of a scale model antenna system (feed and reflector). Design of a mobile antenna will also commence.

During FY 1983, efforts will continue to develop 60-GHz communications components with a multigigabit capability, and an integrated low noise receiver for intersatellite link applications. The Ka-band work will continue in an effort to produce a high performance receiver. The communications technology work in support of deep space missions will continue with efforts to produce a flight model x-band 20/40 watt solid state transmitter.

The massively parallel processor, a major achievement in NASA's data systems technology program, will be completed during FY 1983. It features a six billion instruction/second processing rate for certain classes of problems. The technology, which enables on-line access to large volumes of space data products by geographically diverse investigators, will be demonstrated. It features 50 megabit/second data ingest and retrieval rates with data available within minutes after receipt from a spacecraft. A functional engineering model of an onboard orbit determination system using a global positioning system receiver and microprocessor will be completed. This will provide low cost operational onboard orbit determination capability for future missions.

The superfluid helium experiment will be flown on Spacelab-2. The feature identification and location experiment will be reflown on OSTA-3 to gather additional statistical data on a wide variety of scenes.

Spacecraft Systems Research and Technology

The objective of this program is to develop and demonstrate technology for large space systems, advanced planetary spacecraft, and advanced Earth-orbiting spacecraft to enable current and future space missions. The program extends the accomplishments of the research and technology programs in the fundamental discipline areas to integrated activities such that the transfer of a complete capability is possible. Research and technology activities are conducted in areas where a multidisciplinary approach is essential to accomplish stated objectives. These activities share the common goal of eventual transfer and use of the technology in future spacecraft. This goal requires establishment of technical feasibility and verification of acceptable levels of risk and cost.

In the large space systems technology program, effort is directed toward spacecraft systems research and technology for application to large antennas, large space platforms, and manned space systems. The technology supports spacecraft development for missions in communications, astrophysics, radiometry, science and applications, space power generation, and operations in space. The objectives of the large space systems technology program are to define, develop, and demonstrate system level technologies for space missions which require large spacecraft structures and advanced discipline and subsystem technologies.

In FY 1982, new antenna concepts utilizing membrane reflectors and truss structures are being developed, advanced distributed control systems were configured for large flexible antennas, and full-scale ground development hardware was fabricated and assembled for the 50-meter hoop column and 55-meter wrap rib antennas. Structural assembly tests in the Neutral Buoyancy Facility have been completed utilizing man and machine-assisted techniques.

The advanced Earth-oriting spacecraft program focuses on the systems and discipline technologies for Earth-observing spacecraft required for operational land monitors, meteorological instruments, and future scientific observations. In FY 1982, the instrument requirements document, which will guide development of future Earth-looking sensors and instruments, was completed; a power systems automation task was initiated, functional requirements were identified, and the development of the large deployable solar array continues on schedule toward a test in FY 1983 as a method to understand the dynamics and control characteristics of large structures. The planetary spacecraft systems activity emphasizes the development on advanced systems and subsystems concepts which enable future lower cost planetary exploration. The primary efforts are in the area of advanced mission and spacecraft concepts and spacecraft automation concepts to reduce cost of mission operations and increase mission reliability.

In the large structures program, the full-scale hoop column and offset wrap rib antennas will be utilized for ground tests to determine and understand mesh management techniques, structural characterization, reflector surface precision, and the effects of surface distortions on RF performance. The electrostatic membrane antenna concept for curved and flatback electrodes will be evaluated. Deployable platforms will transition to a ground development program with activities in analysis, design, and fabrication and subsystem integration. Space assembly technology concepts will be developed through analysis and ground simulations. In addition, the structural assembly deployment experiment will be developed to correlate flight operations to ground simulations.

The fabrication and ground testing of the large solar array experiment will be completed in preparation for a late FY 1983 flight test aboard the Shuttle.

Conceptual development of an autonomous spacecraft system will be initiated leading to breadboard systems development and test in FY 1985. In power systems, automation systems requirements will be identified, trade-off assessments of options will be conducted, and system selection for subsequent demonstrations will be completed.

Transportation Systems Research and Technology

The objectives of this program are to identify the technology requirements for advanced transportation vehicles to satisfy national needs and integrate these requirements into a comprehensive plan that results in transfer-ready technology to support projected development schedules; to develop technology programs which satisfy these requirements; and, to support the development, enhancement, and improvement of the space transportation system in areas of technical competence. These objectives are accomplished through system level studies, analyses, and requirement definition efforts, as well as system and discipline research and technology efforts utilizing ground-based facilities, in-space hardware, and instrumentation which permits the Shuttle orbiter to be used as an advanced research vehicle.

During FY 1981, the analytic and ground-based test programs which established the aerodynamic/aerothermodynamic performance envelopes for the early Shuttle flights and supported the certification of the thermal protection system prior to the first flight were completed. First flight data from both the orbiter development flight instrumentation and the orbiter experiments (OEX) program were correlated with preflight, analytical predictions, and ground test data. No significant anomalies were discovered.

On the first Shuttle flight, instrumentation developed by the OEX program for the calculation of the actual aerodynamic coefficients of the orbiter during re-entry was flown. It provided essential data to support the above analysis. This hardware and instrumentation which validated tile gap heating predictions and the noncatalyticity of the orbiter thermal protection system's surface during entry heating were flown on the second Shuttle flight. Sensors which measured the payload environment in the cargo bay were also flown on the second flight. The data collected from the flight will be used to calibrate the environmental, structural, and acoustical load models used to test subsequent payloads configurations. Instrumentation packages which will provide data on other aerodynamic/aerothermodynamics and static/dynamic load characteristics are being developed for subsequent Shuttle flights.

Two significant orbit transfer vehicle studies were completed in FY 1981. The first addressed technology for a mid-1990's vehicle, and the second addressed propulsion options for a post-2000 vehicle. The first study emphasized the merits of aero-assisted recovery and space-basing of reusable vehicles, and technology programs to address critical issues were initiated. The second study identified the critical technology drivers for a post-2000 Shuttle replacement vehicle. It was limited to an assessment of the thermal structure requirements for a totally reusable, integral tankage vehicle.

System analysis efforts will be conducted to define the scope and direction of technology programs needed to reduce the cost or improve the performance of future space transportation vehicles. The efforts initiated in FY 1981 are to address the implications of advanced propulsion systems and thus significantly increase the comprehensive data base on advanced vehicle technology requirements. The study to identify the system levels requirements for the use of aero-assist to recover reusable orbital transfer vehicles will be expended to define specific technology implications of manufacturing orbit transfer vehicle propellants in space, conceptual definition of large plane-change vehicles to permit an assessment of competing options, and program development for automated rendezvous and docking.

In addition to the aerodynamic coefficient and thermal protection system packages noted above, other instrumentation packages developed under the OEX program will be flown on FY 1983 Shuttle flights. These include low and high altitude research-quality air data systems, a leeside temperature sensing system, and a more accurate vehicle coefficient determination package. These will be integrated into Orbiter-102 during the refurbishment effort after Shuttle flight eight.

An OEX program package to quantify the aerodynamic heating (and thus the requirements of the thermal protection system and its limitation) on the windward side of the orbiter during reentry will be flown in conjunction with some FY 1983 flights. The instrumentation is mounted on the C-141 Kuiper Aircraft Laboratory and produces an infrared image of the orbiter at a selected reentry condition.

All Shuttle flights flown in FY 1983 will provide flight data which will be analyzed to validate analytical and test techniques. This data will provide a validation, research-quality data base which describes critical vehicle characteristics, thus permiting advanced vehicle concepts and design to be analyzed with reduced uncertainty and increased confidence.

Two flight control experiments will be integrated into the orbiter in FY 1983. The first experiment will quantify the actual effect of orbiter actuators on vehicle altitude. The second experiment will provide flight data on an advanced, adaptive, semiautonomous autopilot. These data will permit the supporting technology programs to be responsive to actual flight conditions.

Several advanced thermal protection system test panels will be in development for flight opportunities in FY 1984/1985. These panels will provide actual flight data on more durable, higher performance concepts which could become options for retrofit on the current orbiter fleet, as well as candidates for subsequent orbiters. The panels will provide a validated data base for the termal protection system for advanced post-Shuttle vehicles.

The design of the in-space facility to support technology advancement essential for the management (efficient storage and low-loss transfer) of cryogenic fluids in space will be completed and the development of facility hardware will be initiated. Data for this facility will be first obtained during the FY 1988/1989 Shuttle flights.

SYSTEMS TECHNOLOGY PROGRAM

FISCAL YEAR 1983 FUNDING LEVEL

Space systems studies	....
Information systems technology	....
Spacecraft systems technology	$4,400,000
Total systems technology program	4,400,000

Space Systems Studies

The objectives of the space systems studies program have been to identify and evaluate the technology requirements of advanced system candidates, to investigate future space mission alternatives, to assess the effects of technology advances, and to provide a data base to support technology program selection and program planning.

In fiscal year 1983 this program element will be eliminated. Such systems studies as may be required will be performed within the research and technology base or specific systems technology program.

Information Systems Technology

The objective of this activity is to develop the generic satellite communications technology which opens new spectral bands, promotes conservation of the electromagnetic spectrum and geostationary orbit, and facilitates the development of innovative, low cost satellite communications services to the public. Research and technology efforts in satellite communications cover basically two activities: (1) 30/20 GHz communications, and (2) narrowband communications, with the objective of providing technologies to enable affordable communication options for missions in the 1990's. During fiscal year 1982, this activity was descoped as part of the agencywide reduction, and the remaining elements were funded within the information systems program in the research and technology base.

In fiscal year 1983, essential elements of this program will be carried out within the information systems program in the research and technology base.

Spacecraft Systems Technology

The objective of this effort is to provide the capability to extend research and technology activities into the environment of space using the Space Shuttle, the Spacelab, and free-flying vehicles. Research and technology programs are so extended when the unique space environment is essential to the programs of the effort, when an in-space test is cost effective, or when an in-space verficiation will accelerate the utilization of advanced technology. This effort provides an effective means to demonstrate technology readiness so that the advanced technology capability can be used for important space missions at an acceptable cost and risk.

The activity includes the development, integration, and flight operations of experiments to be conducted in the Spacelab, the development of the Long Duration Exposure Facility (LDEF), the development and integration of experiments for the first LDEF missions, and a flight demonstration of an Ion Auxiliary Propulsion System on a free-flying Air Force satellite.

The Spacelab experiments are proceeding on schedule to meet currently defined launch dates. In FY 1982, the LDEF was removed from storage as the first in a lengthy sequence of activities in preparation for an FY 1984 launch. The 8-cm Ion Auxiliary Propulsion System demonstration on the USAF P80-1 spacecraft is scheduled for FY 1984. During FY 1982, systems qualification tests will be performed. Following these tests, the hardware will be shipped to the P80-1 contractor for integration into the spacecraft.

In FY 1983, considering current Shuttle launch scheduling, the following experiments will be launched: (1) solar array flight experiments; (2) solar cell calibration facility; and (3) the tribology experiment. Other experiments will be in various stages of completion for launch in FY 1984 and FY 1985.

During FY 1983, final thermal and structural analysis of the LDEF will be completed, experiments will be completed and integrated into the facility, and the facility will undergo final integration and test before integration into the Shuttle bay.

Integration of the 8-cm Ion Auxiliary Propulsion System to the USAF P80-1 spacecraft and integration testing will be completed in preparation for a FY 1984 launch.

STANDARDS AND PRACTICES

FISCAL YEAR 1983 FUNDING LEVEL

Standards and practices	$3,000,000

The objective of the standards and practices program is to provide an agency focal point for all program assessment functions relative to program assurance, safety, standards, practices, and special project activities to insure mission integrity. This includes responsibility for overall review of the technical execution of all NASA programs to assure that the development efforts and mission operations are being planned and conducted on a sound engineering basis with proper programmatic controls. Specifically, the objectives are to: maintain an overview of the technical execution of NASA programs; address technical problems highlighted in reviews; review program plans/project execution; conduct surveys and special investigations related to program execution, reliability, qualty assurance, including parts and materials assurance, and aviation and systems safety; develop policies; monitor compliance; issue experience bulletins on program assurance related issues; develop handbooks and guidelines governing reliability, quality assurance, software, safety, and other practices; and, to participate with the interagency and industry groups in activities fostering better cooperation on programs and issues of mutual interest.

During FY 1981, the major effort was the completion of an independent review and assessment of the adequacy of the STS-1 flight verification certification program. Reliability and quality assurance activities included continued emphasis on materials integrity; integrated circuit product assurance; software assurance; and increasing attention to materials and parts assurance. The National Bureau of Standards investigation of reliable nondestructive test methods for aluminum alloys 2219 and 2024 is nearing completion, as is the handbook on microcircuit radiation effects. Program practices activities included a program evaluation effort to explore development of an index of risks related to spacecraft design and development, and the completion of a computer data bank pilot project, a listing of current flight-qualified NASA equipment and similar equipment available from industry. Use of the data bank was insufficient to warrant continuation of the effort. Design and manufacturing standards activities emphasized workmanship standards, environmental engineering standards for Space Shuttle payloads, support to the measurement of the Shuttle payload bay dynamic, acoustic and thermal environment, and an assessment of industry practices to mininize damage or loss of electronic microcircuit parts due to electrostatic discharges. In the area of safety, the development of a NASA/Department of Defense ground safety document was successfully completed, and the characterization of hazardous aerospace materials continued. In response to Congressional direction, a contractural relationship was established with the National Academy of Sciences/National Academy of Engineering to provide an independent capability to review major NASA program changes at the requests of the Committees on Appropriations.

In support of the objectives of the Agency, the FY 1983 standards and practices program will continue to conduct activities related to reliability and quality assurance, systems and aviation safety, software assurance, and program practices to reduce program risks, improve product confidence, and encourage good program practices in the technical execution of NASA programs. The FY 1983 standards and practices program principally provides for continuity in addressing engineering and technical concerns related to the NASA space program activities. For this budget year, the funding estimates do not project any major departures from the prior year activities. Standards and practices will continue to maintain an overview of the technical execution of NASA programs, address technical problems highlighted in reviews, review program plans and project execution, evaluate technical readiness of systems to perform missions, and conduct surveys and special investigations related to program execution, reliability, quality assurance, and systems safety. In each of the cognizant areas, activities are anticipated and programs will be conducted which assist the rapid identification and solution of technical problems that surface at technical reviews or are encountered in test or operational program activities, or which will contribute to the long-range goal of increased confidence in the ability of the programs to meet their mission goals. Increased emphasis is planned in FY 1982 and FY 1983 in systems and aviation safety related activities, and in support of improved management of software in NASA programs.

11. TRACKING AND DATA ACQUISITION, $498,900,000

FISCAL YEAR 1983 FUNDING LEVEL

Operations	$338,200,000
Systems implementation	96,000,000

Advanced systems	13,400,000
Tracking and data relay satellite system	51,300,000
Total tracking and data acquisition	498,900,000

The purpose of this program is to provide vital tracking, command, telemetry, and data acquisition support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided for projects of the Department of Defense, and on a reimbursable basis to other Government agencies, commercial firms, and other countries and international organizations engaged in space research endeavors.

Support is provided for sounding rockets, research aircraft, Earth orbital and suborbital missions, planetary spacecraft, and deep space probes. The program also includes the support of all phases of the Space Shuttle flight program. The various types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of scientific and space applications data from on-board experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) transmission of commands from ground stations to spacecraft; (e) communications with astronauts; (f) transfer of information between the various ground facilities and central control centers; (g) processing of data acquired from the launch vehicles and spacecraft; and (h) reception of television transmission from space vehicles. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions, and, in the case of Shuttle missions, to insure safety of the crew.

Tracking and acquisition of data for the spaceflight projects is presently accomplished through the use of a worldwide network of NASA ground stations. When the Tracking and Data Relay Satellite System becomes operational, tracking support will be provided by a system of tracking and data relay satellites in geosynchronous orbit. Ground facilities are interconnected by ground communications lines, undersea cables, and communications satellite circuits which are leased from communications carriers, both domestic and foreign. This interconnection provides the communications capability needed between spacecraft and the control centers from which the flights are directed.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has established three basic support capabilities to meet the needs of all classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports Earth orbital missions; the Deep Space Network (DSN), which supports planetary and interplanetary flight missions; and the Tracking and Data Relay Satellite System (TDRSS), which will provide all low Earth orbital mission support when it becomes fully operational. The STDN will remain the primary Earth orbital support network until three TDRSS spacecraft are launched, properly positioned, and have completed pre-operational testing to insure reliable mission operations support.

When the TDRSS is fully operational, a phaseout of STDN ground stations will be initiated. Certain facilities of the STDN will be retained to provide support to geosynchronous and highly elliptical missions which cannot be supported via the TDRSS. These remaining facilities are planned to be consolidated with the DSN stations under the management of the Jet Propulsion Laboratory. The consolidation is keyed to providing a single network in the mid-1980's to support synchronous, highly elliptical, and planetary missions while reducing operations and maintenance costs.

Computation facilities are maintained to provide real-time information for mission control and to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

The Research and Development appropriation provides funds for: (a) operations and maintenance of the worldwide facilities; (b) the engineering and procurement of equipment to sustain and modify the network systems to support continuing, new, and changing flight project requirements; (c) the investigation and development of advanced tracking and data acquisition systems and techniques; and (d) the cost of the TDRSS services beginning in FY 1983.

OPERATIONS

FISCAL YEAR 1983 FUNDING LEVEL

Spaceflight tracking and data network	$184,500,000
Deep space network	61,300,000
Aeronautics and sounding rocket support	6,900,000
Communications operations	45,600,000
Data processing	39,900,000
Total operations	338,200,000

Funds requested for operations provide for manpower and services needed to operate the worldwide network of NASA ground facilities including tracking stations, mission control centers, computation and data processing facilities, and support instrumentation for sounding rocket and aeronautics programs, and to provide the communications required in support of NASA programs. The FY 1983 funding request provides support to approximately 50 automated Earth orbiting and planetary missions. The funds requested for operations also provide for support of Space Shuttle flights and for the prelaunch support activity required for upcoming approved programs such as Spacelab, Gamma Ray Observatory, Galileo, Tracking and Data Relay Satellite System (TDRSS).

The FY 1983 request includes funding for test, checkout, and the initial operation of the TDRSS related ground systems as well as the continued operation of the Spaceflight Tracking and Data Network. To minimize the funding requirements during this transition to TDRSS operations, along with minimal provision for escalation, the actions described earlier concerning station and facility closures and staffing reductions have been taken.

Spaceflight Tracking and Data Network Operations

The primary function of the Spaceflight Tracking and Data Network System (STDN) is to support all NASA Earth orbital spaceflight missions, including the Space Shuttle. The majority of these missions have near-Earth orbits; however, the network also supports selected missions through lunar distances and beyond, such as the International Sun-Earth Explorer missions. In addition, the network provides launch support to NASA automated planetary missions, the Department of Defense and on a reimbursable basis, spaceflight missions of other nations, commercial firms, and other United States government agencies. Accordingly, the network must be responsive to the requirements of a large number and wide variety of flight projects from launch through completion of the flight project objectives. In many instances, the period of network support required by flight projects continues for several years.

The STDN presently consists of eleven geographically dispersed ground stations. The Tracking and Data Relay Satellite System will consist of four spacecraft; two for NASA service, and one for commercial service, and an on-orbit spare, a single ground station at White Sands, New Mexico; and associated control, communications, and computational support facilities. Control centers for the STDN and TDRSS, the operations support computing facility, and a mission control center complex are located at the Goddard Space Flight Center (GSFC) which has the field center management responsibility for these programs.

These global facilities have the capability to electronically track the spacecraft, send commands for spacecraft and experiment control purposes, receive and display engineering and scientific data from the spacecraft, and in the case of manned flights, maintain voice communications for crew safety and other project related purposes.

In addition to the station and operations facilities at GSFC, ten STDN land stations are located at Fairbanks, Alaska; Goldstone, California; Merritt Island, Florida; Kauai, Hawaii; Guam; Ascension Island; Canberra, Australia; Bermuda; Santiago, Chile; and Madrid, Spain. Separate operations contracts exist for the Australian, Chilean, and Spanish sites with the balance of network operations and maintenance covered in a single procurement. A separate contract exists for network logistics support. A transportable station is located near NASA's Dryden Flight Research Facility (DFRF), California, for support of the Shuttle program. An additional small transportable station is located at New Smyrna Beach, Florida, for support of Shuttle missions. Also, four UHF/voice air-to-ground stations were established for additional Shuttle support, with one augmented for S-band operations. An engineering test and network system training facility at GSFC is also maintained and operated as part of the STDN.

The STDN has provided support to approximately 45 automated applications and space science spacecraft during the past year. Examples of significant missions being supported include Shuttle, Landsat-2 and -3, three Applications Technology Satellites (ATS-1, -3, and -5); Solar Maximum Mission; two Dynamics Explorer missions (DE-1 and -2); Solar Mesosphere Explorer (SME); Nimbus-5, -6, and -7; the International Sun-Earth Explorers (ISEE-1, -2, and -3); and the International Ultraviolet Explorer (IUE). Upcoming missions to be supported include the Space Telescope, Landsat-D, the Gamma Ray Observatory, and the Space Shuttle operational missions. The overall spacecraft support workload of the STDN is projected to total approximately 45 missions during 1982.

The FY 1983 funding requirements provide for the maintenance and operation of the STDN and mission facilities required for the command and control of automated spacecraft. The request also includes funds for the staffing, software development, and test and training activities necessary for the initiation of TDRSS operations in FY 1983. Also provided are the related logistics, supplies and network planning, scheduling, engineering, documentation, and software programming costs associated with the around-the-clock operation of the network.

The request for fiscal year 1983 is based upon a substantial STDN support workload along with other program activities, including the initiation of TDRSS services, commencement of Shuttle operational flights, support of the Landsat-D, and implementation of network consolidation.

The increase from fiscal year 1982 to fiscal year 1983 reflects the funding required to provide ongoing support to the TDRSS such as data flow testing of the TDRSS related ground systems and to complete the basic software capabilities of the Network Control Center. The request also contains funding for achieving the staffing levels necessary for operating the TDRSS related ground systems including initial operation of the Network Control Center. The functions performed by ground systems, such as the scheduling and monitoring of the TDRSS service, is required for support to user missions during the latter part of fiscal year 1983. In addition funds are required to provide for cost escalation, and a transfer of the orbit determination and computation function from the data processing operations budget line item to the STDN operations budget. This transfer is being undertaken to achieve greater consistency between the budget and program management responsibilities in the Office of Space Tracking and Data Systems as the transition is made to TDRSS operations.

Deep Space Network Operations

The primary function of the Deep Space Network (DSN) is to support planetary and interplanetary spaceflight missions. The DSN provides the vital two-way communication link by which distant spacecraft are controlled and scientific data is acquired. As the planetary missions become more complex and flight distances continue to increase, this network requires systems software and operational techniques that push the state-of-the-art in telecommunications.

The DSN stations are located at Goldstone, California; Canberra, Australia; and Madrid, Spain. The three DSN station locations are approximately 120 degrees apart in longitude and permit continuous viewing of the planetary spacecraft. The stations consist of one 64-meter and one 34-meter diameter antenna at each location. As an economy measure, and with the Voyager II in a cruise phase to Uranus (requiring minimal support), a decision was made to close the 26-meter antenna subnetwork. A centralized control center for the network is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. JPL has field management responsibility for the network. Separate contracts exist for the operation of the Australian, Spanish, and Goldstone sites. The contract for the Goldstone station also includes network support activities and operation of the network control center at JPL.

The current workload in the Deep Space Network consists of seven ongoing Pioneer spacecraft (Pioneer 6–11 and Pioneer Venus), the Viking 1 Mars Lander, one Helios mission, and two Voyager spacecraft. Support of these missions will continue during fiscal year 1983.

The Deep Space Network provided excellent support to the August 1981 encounter of Saturn by Voyager II. This encounter returned some 12,000 images through the Deep Space Network utilizing an arrayed antenna technique. Voyager 1 is now about 1.8 billion kilometers from Earth on a trajectory that will take it out of the Solar System.

Of the older Pioneer spacecraft, Pioneer 10 is over 3.7 billion kilometers from Earth, and along with Pioneer 11 is proceeding on a path that will take them beyond the solar system. Pioneer 10 continues to be the most distant man-made object communicated with and each time data is received by the deep space network, a new communications record is established. It now takes nearly seven hours for a radio signal traveling at the speed of light to make the round trip between Earth and Pioneer 10. The Pioneer 11 spacecraft, some 1.8 billion kilometers from Earth, continues to be tracked. The Pioneer 6–9 spacecraft are provided support during solar conjunctions and during gravity wave experiments. The Helios 1 mission is continuing its orbit about the Sun and the Viking Lander continues to gather scientific data from Mars.

The Deep Space Network facilities are also used on a noninterference basis for ground-based measurements in support of experiments in planetary radar mapping and in the field of radio astronomy. The ultrasensitive network antennas are being used in an attempt to learn more about the mysterious pulsar high energy sources, quasars, and other interstellar phenomena.

In addition to the activities associated with the network modifications and the support cited above, the DSN workload includes preparation for several future missions including the International Solar Polar spacecraft, the Galileo spacecraft (orbiter and probe), and the reimbursable European Space Agency (ESA) mission to Halley's Comet (Giotto). This support preparation requires thorough and complex testing, training, and engineering (both hardware and software). These activities must be carried out simultaneously with the extensive and continuous ongoing DSN support workload, and must be done in such a way as to cause minimum disruption to ongoing flight project support.

The DSN operations funding provides for the maintenance and operation of the network facilities, control center, and the support and engineering effort associated with the operations of the network. Separate contracts have been established under international agreements for operation of the tracking facilities in Spain and Australia. The funds requested for fiscal year 1983 are based upon the ongoing workload, including the Voyager missions, the Pioneer 6–11 missions, the Pioneer-Venus extended mission, the Helios mission, and the Viking Lander mission. The decrease from fiscal year

1982 to fiscal year 1983 is due principally to the closure of the 26-meter subnet, which is largely offset by escalation.

Aeronautics and Sounding Rocket Support Operations

Fixed and mobile instrumentation systems are maintained and operated to support sounding rocket, balloon, spacecraft, and aeronautical programs conducted by the Wallops Flight Center (WFC) and the aeronautical flight research programs of the Dryden Flight Research Facility (DFRF). These instrumentation systems include radar, telemetry, data processing, data handling, and communications systems, as well as special purpose optical equipment.

The sounding rocket program continues to be an active program with approximately 135 launches in 1981, the majority of which were conducted at WFC. In addition, there were over 40 balloon flights during the same period. At WFC, the aeronautical programs are primarily related to investigations of aircraft handling characteristics, advanced control and display concepts, spin and stall tests, terminal area guidance and traffic control systems, and noise studies. Approximately 200 missions were conducted during 1981. In addition to support of sounding rocket, balloon, and aeronautical programs, instrumentation at WFC will continue to be utilized to support the Shuttle orbital flight tests (OFT).

Dryden Flight Research Facility operates the aeronautical test range which provides radar, telemetry and communications support for the performance of aircraft research and development programs. A variety of programs are conducted involving high performance aircraft, such as the F-111, F-14, F-16, F-104, F-8, and research vehicles such as the tilt rotor research aircraft, highly maneuverable aircraft technology, drones for aerodynamic and structural testing, and other remotely controlled spacecraft. Over 200 aeronautical research missions were supported at DFRF during CY 1981. Dryden Flight Research Facility is the prime landing site for STS-3 and STS-4 and tracking and data acquisition support of the Shuttle orbital flight tests will continue.

The fiscal year 1983 funding requirements provide engineering and technical services for maintenance and operation of fixed and mobile radar, telemetry, communications, data handling, and processing equipment and facilities to support the ongoing sounding rocket, balloon, and aeronautical research activities.

Communications Operations

NASA's global communications network (NASCOM) interconnects, by means of leased voice data and wideband circuits, the tracking and data acquisition facilities which support all flight projects. NASCOM also links such facilities as launch areas, test sites, and mission control centers. Goddard Space Flight Center (GSFC) operates the NASCOM and serves as its major switching control point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at key domestic and overseas locations.

The NASA flight projects require the transfer of data between the mission control centers and the tracking sites because of the need for real-time control of spacecraft and on-board experiments.

In addition, there are requirements to provide experiment data expeditiously to users for analysis.

In order to meet high data transfer rate requirements, NASA has made and will continue to use digital techniques in providing communications support. The availability of this technology allows greater amounts of data to be sent over conventional communication circuits. Circuits capable of transferring data at increasingly higher rates continue to become available from the common carriers at reasonable costs. Consequently, the techniques of sending data directly from a spacecraft, through a tracking station without manipulation, to a mission or project control center have become economically attractive and are used extensively in NASA's global communications network. This approach simplifies the data handling systems at the tracking stations, thereby minimizing the operation and maintenance activities at those locations.

The FY 1983 funding requirements for communications operations will provide for the circuits and service required to operate and maintain the NASA global communications network. International communications satellites and cables will continue to be used to provide digital wideband services to all the overseas tracking stations. The domestic satellite systems and terrestrial networks will continue to service the continental United States stations. These services will provide for real-time transfer of data for all ongoing flight programs.

The major increases in FY 1983 are due to the activation and test of the 50 megabit digital wideband service from the Tracking and Data Relay Satellite Sytem facility at White Sands to both the Goddard Space Flight Center and the Johnson Space Center in support of Spacelab and Landsat-D Thematic Mapper high data rate requirements, a 4.0 megabit baseline capability from White Sands to handle the lower data rates required for Shuttle and Landsat-D support and escalation.

Data Processing Operations

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. This transformation and computation process is performed as part of the data processing function and applies to a wide variety of programs, ranging from the small Explorer satellites to complex Landsat satellites.

Tracking data is processed to provide orbital information which is used to compute spacecraft position. This is essential for the real-time control of spacecraft, for determining when the spacecraft will be passing over the stations so data can be acquired, and for providing precise information that can be used by the scientific experimenters to determine where in the trajectory of the spacecraft the scientific measurements were made. Telemetry data must be processed to: (a) separate the information obtained from various scientific experiments aboard the spacecraft; (b) consolidate information for each experiment; (c) determine spacecraft attitude; and (d) correlate these measurements with the position data. Processed data is the primary product of the spacecraft missions, and it is through reduction and analysis of this data by the experimenters that the planned objectives are achieved.

In addition to the actual processing of the data, upcoming projects require extensive prelaunch orbit analysis including spacecraft position and attitude predictions. Analyses are also required to develop operational sequences and procedures to be used during the actual operation of these complex spacecraft. Examples of these activities are: (1) the final checkout and acceptance of the operational orbit support software for the first Tracking and Data Relay Satellite launch early in 1983, and (2) the analysis and development of the operational software for the bilateration ranging transponder system for the support of the Tracking and Data Relay Satellite System and (3) final checkout of operational orbit software for the Landsat-D launch in mid-1982.

As part of the data processing activities, there is a significant effort required to process original or raw information received from the on-board experiments. Two facilities, the Imaging Processing Facility (IPF) and the Telemetry On-line Processing System (TELOPS) have been established at the Goddard Space Flight Center to process different types of raw experimental data.

The IPF initially established to handle imagery data from the Landsat-1, continues to support the second and third Landsat spacecraft as well as Nimbus missions. These spacecraft are supported with an all digital system using high density and computer compatible tapes which have reduced the time required to provide data to users.

The Telemetry Processing Facility which handles the conventional, nonimagery data was reconfigured in FY 1978 as the TELOPS. This reconfiguration resulted in a change from a tape-oriented system to an automated on-line electronic mass storage system. TELOPS receives satellite data in a digital form from the tracking stations via the NASA global communications network lines and is able to electronically store large volumes of telemetry data, thus eliminating most of the tape and tape handling operations. Maintenance and operations support for the image and nonimage data processing facilities is provided by a single contractor. There are two other contracts under which software development and maintenance is provided for new systems along with software for attitude determination, flight maneuvers, support scheduling, and mission simulations.

The FY 1983 budget request includes funds to operate the Image Processing Facility and the Telemetry On-line Processing System to process data from currently orbiting satellites and from missions scheduled to be launched through FY 1983. The requirements for the acquisition and processing of data from the older satellites are under continual review as support for older missions is terminated or curtailed, as mission objectives are achieved, or when the experiment data is no longer useful or cost effective to acquire and process. A facility to support Spacelab missions will be completed during mid-1983 and prelaunch operations and training will begin. The maintenance and operation of the Image Processing Facility, Telemetry On-line Processing System, and the Spacelab facility will be under a single contract.

Software development activities are continuing or will be initiated in support of upcoming space science and applications missions such as Space Telescope, Landsat-D, Earth Radiation Budget Satellite, Cosmic Background Explorer, and the Gamma Ray Observatory. Complex software is required for spacecraft on-orbit and attitude control maneuvers and for the related data processing activities. Software effort is also required to develop the necessary programs to accommodate spacecraft which will operate with the Tracking and Data Relay Satellite System.

The funding request in FY 1983 reflects the transfer of the orbit determination and computation functions to the space tracking and data network operations discussed under that section.

SYSTEMS IMPLEMENTATION

FISCAL YEAR 1983 FUNDING LEVEL

Spaceflight tracking and data network	$22,400,000
Deep space network	44,800,000
Aeronautics and sounding rocket support	[illegible],800,000
Communications	5,600,000
Data processing	19,400,000
Total systems implementation	96,000,000

The objectives of the NASA tracking and data systems implementation program are to maintain the existing ground support capability at a high level of proficiency and reliability in order to meet the support needs of the many and varied space missions, and to provide augmentation of this capability, as necessary, to meet the special requirements of individual flight projects. These ground support systems consist of the tracking and communications networks, control centers, data processing facilities, and aeronautics and sounding rocket support instrumentation. The systems implementation program encompasses the engineering, design, and procurement of the necessary equipment, subsystems, and systems in response to the requirements of the various flight missions and other research projects. It also includes related documentation and basic software, the purchase of large module spares, and the acceptance testing, integration, and checkout of equipment.

FY 1983 funding is needed to maintain the operational proficiency and reliability of network systems through the replacement of obsolete and worn out equipment. Modification and augmentation of existing systems are also necessary to maintain compatibility with changes in associated on-board spacecraft communications systems and to improve the utilization and efficiency of network systems. In addition, FY 1983 funds are required to continue the implementation of new capabilities for upcoming missions, including Galileo, Space Telescope, and Spacelab. Implementation activities continue at the Network Control Center and the NASA ground terminal at White Sands, New Mexico, and with other Tracking and Data Relay Satellite System (TDRSS) related systems for the initiation of TDRSS service in FY 1983.

Funds are included as part of a phased program for the consolidation of the remaining Space Tracking and Data Network stations with the Deep Space Network stations after the tracking and data relay satellite system is operational and to provide an imaging capability for the Voyager Uranus encounter in January 1986.

Spaceflight Tracking and Data Network Systems Implementation

The Spaceflight Tracking and Data Network systems implementation program encompasses the procurement and implementation of systems and services to: (1) sustain network facilities and equipment to insure reliable support of ongoing scientific and applications satellite missions, (2) to provide the necessary network and control center capabilities to perform the required control, tracking, command, and data acquisition functions in support of all NASA Earth orbital missions, including new support requirements for spacecraft to be launched in the near future. Implementation of these capabilities is vital to the success of NASA's spaceflight missions.

Employing systems implemented in past years, the network is currently supporting many missions with highly complex requirements for tracking, data acquisition, command and control. Software development is continuing for the Network Control Center (NCC) in preparation for the upcoming TDRSS launches and initiations of service. Plans and procurements are also underway to meet support requirements for upcoming missions such as Spacelab and Space Telescope. Compatibility testing and checkout activities for the Tracking and Data Relay Satellite System related ground systems will be completed in accordance with the plan to initiate Tracking and Data Satellite System service during FY 1983.

Equipment modifications are required in the network and control centers in FY 1983 to maintain the required level of proficiency to support a diverse and demanding workload and to assure the reliability of the major systems. Accordingly, funds are required to replace portions of aging systems, for equipment modifications to correct operational deficiencies, and for equipment to be used in operational control of the network. The funds requested also provide for procurement of major subsystem spares, for the provision and modification of test equipment, and for minor equipment modifications resulting from changes in support requirements from one mission to the next.

Funds are requested to complete the implementation activities for an operational Tracking and Data Relay Satellite System including integration and compatibility testing for the bilateration tracking system, the NASA Ground Terminal, the interconnecting communications devices and other portions of the Tracking and Data Relay Satellite System. User oriented analysis on transponder power, communications margins, and interference effects are conducted on a continuing basis to ensure appropriate user support with the Tracking and Data Relay Satellite System.

In FY 1983, effort will continue on implementation of the control center for the Space Telescope mission. The funds requested provide for the control center hardware, for software used in telescope pointing, generation of command sequences for the spacecraft computer, and calculation of spacecraft attitude. Test and verification of the in-place portions of the control center and ground control tests of the spacecraft experiments will take place in FY 1983.

Deep Space Network Systems Implementation

The role of the Deep Space Network is to provide the communication link between each of NASA's distant planetary and interplanetary spacecraft and the Earth. The Deep Space Network is responsible for receiving science data, and providing the navigation, command and control capabilities from the ground to a constellation of spacecraft ranging out to over 3.7 billion kilometers from Earth, (an ever-increasing range). In addition, after the Tracking and Data Relay Satellite System becomes operational, the Deep Space Network will also support spacecraft much closer to Earth. This new set of spacecraft will include highly elliptical Earth orbiters and synchronous Earth orbital missions which will be in orbits higher than those supportable by the Tracking and Data Relay Satellite System.

The systems and facilities required to accomplish this unique support are highly specialized and include the use of large aperture antennas configured in a phased array for optimum reception of the extremely weak radio signals, ultrasensitive, cryogenically cooled receivers and highly powered transmitters. Extremely stable cryogenic hydrogen maser time standards are required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the deep space network complexes and the Network Control Center.

The four major objectives for the Deep Space Network in the 1980's can be summarized as follows: (1) to provide communications channels to scientific spacecraft at ever-increasing distances and to provide the capability to receive clear images at these great distances; (2) to consolidate the activities of the residual Spaceflight Tracking and Data Network with the Deep Space Network after the Tracking and Data Relay Satellite System becomes fully operational in 1984 to increase operational flexibility and reduce overall operating costs; (3) to provide support for a new set of spacecraft which will include highly elliptical Earth orbiters and synchronous Earth orbital missions (both types will be in orbits above the area supported by the Tracking and Data Relay Satellite System); and (4) to provide the improved navigation capabilities required for precise spacecraft targeting and probe delivery.

These objectives represent a significant challenge to the Deep Space Network, as it will be supporting many more spacecraft than in the past, and it will be working at incredibly great distances (4.5 billion kilometers—three times the distance to Saturn) by the end of the decade.

Following the Voyager II Saturn Encounter in August 1981, the next major planetary encounter will be of Uranus by Voyager II in 1986. This encounter will occur some 4.5 billion kilometers from Earth. At that time, Voyager II is expected to transmit the first images ever received from a spacecraft at such a distance. The newly consolidated network will receive its first major test of multiple antenna arraying (more than two antennas) during this Uranus encounter. In addition, the design and implementation of the new consolidated network must provide the flexibility necessary to support near-Earth missions that cannot be supported by the Tracking and Data Relay Satellite.

New deep space missions which will be supported by the network in the 1980's include a Jupiter orbiter and probe (Galileo) and the International Solar Polar Mission. One or more of Halley's Comet rendezvous missions will also be supported for the international community on a reimbursable basis.

Funding in the fiscal year 1983 request provides for continuing the reconfiguration of the ground network facilities into a consolidated, modern, and highly reliable, automated network. The capabilities planned in the reconfiguration will provide for enhanced spacecraft-ground telecommunications and navigation precision while reducing overall maintenance and operations costs.

The overall design will allow antennas to operate either independently (with different individual spacecraft) or in an arrayed fashion (more than one antenna targeted on a single spacecraft) to achieve the increased aperture necessary to support the high data rates of missions such as Voyager II at Uranus. (As the distance to the spacecraft doubles, the antennas aperture needed to provide an equivalent signal goes up by a factor of four, resulting in the need for increased antenna aperture at Uranus, which is twice the distance that Saturn is from Earth.) Thus, this design provides for an improved flight project support capability and also allows for a reduction in operations and maintenance costs. Equipment required for this capability includes antenna monitor and control, receiving, and data handling systems, along with the necessary engineering and fabrication.

In addition, funds are included for implementing a central signal processing center at each Deep Space Network complex. Instead of having independent support facilities for each antenna, it will be possible to control all antennas at each complex from a central operations center. This center will include the digital electronics required for uplink command encoding, downlink demodulation, signal recording, and data transmission for all the antennas in the complex. Centralized and shared maintenance facilities will also be provided.

In conjunction with the evolution of the consolidated network, modifications are planned at the Network Control Center to facilitate scheduling, spacecraft acquisition and tracking, monitor and control, and overall coordination of the activities of the network. Funding also provides for continued development and improvement in flight navigation accuracy and for replacement of obsolete frequency and timing equipment.

Concurrent with these important engineering changes, fiscal year 1983 funds will be required to maintain the high level of reliability for support of time critical spacecraft maneuvers as well as routine ongoing support. This will be accomplished through a continuing program of equipment and facility refurbishment, and modifications to assure compatibility of existing equipment with the new systems being implemented in the network.

Aeronautics and Sounding Rocket Support Systems Implementation

The objective of the aeronautics and sounding rocket support system implementation program is to provide fixed and mobile instrumentation systems to meet the tracking, data acquisition, and range safety requirements of the aeronautical research conducted at the Wallops Flight Center (WFC) in Virginia, the Dryden Flight Research Facility (DFRF) in California, and the scientific investigations conducted with balloons and sounding rockets at Wallops and other selected sites around the world. The WFC and DFRF provide the fixed ground instrumentation systems to support aeronautical research. In addition, WFC provides both fixed and mobile instrumentation to support the sounding rocket program.

The aeronautical research efforts and scientific experiments using sounding rockets and balloons are programs of a continuing nature which require generally the same level of support from year to year. To support these programs, Wallops Flight Center provides fixed and mobile instrumentation systems; namely, radar, telemetry, communications, command, data handling and processing systems. To maintain these facilities, spare and replacement parts must be acquired and test and calibration equipment routinely replaced. Due to the age of some of the radar, telemetry, and impact prediction equipment, a phased program of necessary replacement is underway in order to sustain and improve the tracking and data systems support for these programs. To insure reliable real-time data collection and handling support to meet current and future requirements, an orderly plan to replace obsolete equipment is also underway. Funds are included in the request for the periodic refurbishment and modifications of mobile equipment to meet remote site sounding rocket and balloon support requirements.

Communications Systems Implementation

The objective of the communications systems implementation program is to provide the necessary capability in NASA's global communications network (NASCOM) to meet new program support requirements, to increase the efficiency of the network, and to keep NASCOM at a high data level of reliability for the transmission of data. NASCOM interconnects the tracking and data acquisition facilities which support all flight projects; it also links such facilities as launch areas, test sites, and mission control centers.

The major efforts underway in the NASCOM are the procurement of a control and status system that can remotely control the configuration of the Tracking and Data Relay Satellite System (TDRSS) multiplexing system at White Sands and the implementation of a 50 megabit per second transmission capability connecting the White Sands, Johnson Space Center, and Goddard Space Flight Center for support of Spacelab and Landsat-D missions. Funding is also provided to replace equipment in the message switching system at the Goddard Space Flight Center.

The FY 1983 funding requirements will provide the sustaining equipment and modifications to support the NASCOM network and to complete the replacement of the message switching system at the Goddard Space Flight Center to coincide with the TDRSS communications system which will operate at very high data rates. Efforts will begin to test digital techniques on the wideband data system and to continue efforts on the use of fiber optic cables for distribution of very high data rates from the TDRSS.

Data Processing Systems Implementation

The data processing systems implementation program provides for the procurement of equipment and related services for the large computer complexes at the Goddard Space Flight Center which support both the operational and payload requirements of space missions. To meet operational requirements, these computer complexes determine spacecraft attitude and orbit, and generate commands to the spacecraft that provide the status of on-board subsystems. In support of spacecraft payloads, the computer systems process the data from science and applications experiments for subsequent transfer to the experimenters.

Significant activities in this program continue at the Goddard Space Flight Center to keep the large complexes viable and responsibe to project support requirements. The Telemetry On-Line Processing System (TELOPS) is routinely supporting a number of Earth orbiting spacecraft. The Image Processing Facility is generating products for Landsat, Heat Capacity Mapping Mission, and Nimbus 7. The program to replace many of the old computers continues. The new Metric Data Facility will be on line in mid-1982 and the existing system retired. Implementation continues on a new system to process data from numerous and varied experiments which comprise the payloads of early Spacelab missions.

The FY 1983 budget request will provide continued funding for phased replacement of the existing computer complex at the Goddard Space Flight Center which provides real-time support to the many NASA spacecraft. Included in the support are such critical activities as real-time attitude and orbit determination, memory management for on-board computers, and flight maneuver control. This computer complex is approximately 16 years old. Not only is hardware and software maintenance becoming more difficult and expensive, but the more frequent outages are becoming a threat to spacecraft support. Further, system architecture of the existing systems requires more extensive software development to adopt to new missions.

The FY 1983 funding request provides for continuation of the phased computer replacement program for the flight dynamics and command management systems and initial funding for replacement of the orbit computation system at the Goddard Space Flight Center. The orbit computation replacement system will have a complex task of not only supporting free-flyer spacecraft, but also the Shuttle and the Tracking and Data Relay Satellite System. Maintaining the Tracking and Data Relay Satellite System position accuracy will impose a significant demand on the orbit computation system resources.

While the major portion of the Spacelab Data Processing Facility implementation activity has been acomplished with prior years appropriations, funds are also required in FY 1983 to complete the implementation. This capability is being provided by new equipment as well as augmenting and sharing the existing free-flyer data processing capability. The Univac 1108 computers which are about 15 years old have been replaced with faster central processor units and additional memory; thereby, providing the additional capability required to handle the Spacelab data rates. Funds are requested for upgrading the facility to provide for a more reliable opertion for both Spacelab and free-flyer support.

In addition, funds are required for the implementation of a stand-alone Space Telescope Data Capture Facility which will capture, error check, and ship scientific data to the Space Telescope Science Institute. The system is required for the planned packaged telementry requirement and the long mission lifetime of the Space Telescope. The packaged telemetry concept allows the scientific data of an experiment to be accompanied by the associated ancillary data (spacecraft orbit, attitude, time, etc.) in the downlinked telemetry stream from the spacecraft. This procedure minimizes ground data processing time and complexity as well as insuring faster delivery of data to the experimenters.

There is a continuing reqirement to procure and maintain adequate supply of spare parts to replace failure prone and high maintenance electronic modules, to provide test equipment, and to undertake minor modifications and hardware fabrication associated with new equipment installation and reconfiguration.

ADVANCED SYSTEMS

FISCAL YEAR 1983 FUNDING LEVEL

Advanced systems	$13,400,000

The overall objective of the advanced systems program is to perform studies and conduct the development of tracking and data systems and techniques required to: (1) obtain new and improved tracking and data capabilities that will meet the needs of approved new missions and near term new starts, and (2) improve the cost effectiveness and obtain the reliability needed for overall support of the total mix of spaceflight missions. This effort also includes investigations of upcoming missions and trade-off studies of ground systems and telecommunications links to determine design approaches and overall trade-offs for the lowest life-cycle costs to support future space missions.

This program remains a vital element in the space tracking and data acquisition program. It is through this program that the dramatic changes taking place in the state-of-the-art in telecommunications and computer technology are assessed and applied to future support capabilities. The type of activity undertaken in this program provides the foundation for future planning and for advances in support capabilities that are cost effective and reliable. This is accomplished mainly through contracts at the Goddard Space Flight Center for Earth satellite missions and data systems and by in-house personnel at the Jet Propulsion Laboratory for the deep space missions.

The following are examples of the type of activity for FY 1983. Extremely precise tracking techniques will be investigated for determining planetary mission angular direction and measuring time with accuracy sufficient to track and guide future planetary flybys, orbiters, landers and probe releases, and in the process, to make possible new ground-based science experiments, e.g., search for gravity waves.

New techniques in radio telecommunications will continue to be investigated, especially those that will make more effective use of existing ground facilities. The addition of a K-band reception capability will be investigated. Developments include a cryogenically cooled telemetry receiving system and antenna improvements capable of operating in each of three frequency bands (X, S, and K-bands). Application of K-band technology promises a factor of ten improvement in telecommunications with the option of trade-offs on future missions between spacecraft power and weight and the amount of scientific data returned. Effort will also continue on an X-band uplink transmitting system to increase the Deep Space Network command capability for ground-based navigation and radio science. The use of optical telecommunications in a space relay mode will be investigated for its mission trade-off advantages and its potential for direct link video from the outer most planets.

Earth orbital missions during the Tracking and Data Relay Satellite System era will acquire and process telemetry data at rates up to 300 million bits per second, an increase over current requirements (for Landsat-3) by a factor of 20. These future requirements result from high resolution sensors such as multispectral scanners and synthetic aperature radars. New techniques and systems must be developed for the ground transfer and processing of such large volumes of data. These include computer assisted operations, digital processing of high volume data, improved man-machine interfaces and wide band satellite communications to distribute data to processing centers and the users. Optical disc data storage and automated quality control of data will be investigated in order to meet the increased image data processing requirements anticipated for future Earth observations missions.

TRACKING AND DATA RELAY SATELLITE SYSTEM

FISCAL YEAR 1983 FUNDING LEVEL

Tracking and data relay satellite system	$51,300,000

The objective of the Tracking and Data Relay Satellite System (TDRSS) is to provide tracking, command, and telemetry services to all low-Earth orbital missions. TDRSS will consist of a four satellite constellation in geosynchronous orbit and a single ground station located at White Sands, New Mexico. Of the four satellites on-orbit, two will be dedicated to NASA use, one will provide Space Communications Company commercial service, and the forth will serve as an on-orbit spare to assure the reliability of both NASA and commercial services.

The NASA service will provide both increased high data rate capability and greatly expanded mission coverage over that currently provided via traditional ground stations. When TDRSS becomes fully operational, a number of manpower intensive ground stations servicing low-Earth orbital missions will be phased out.

The first TDRSS spacecraft has completed its integration and environmental testing and is undergoing disassembly to incorporate modifications to provide improved security and Shuttle safety features. All essential ground terminal equipment for initial operations has been delivered and installed at the White Sands station. Software test and checkout, service level testing, and initial data flow and compatibility testing with other NASA systems have been initiated. The launch of the first TDRSS is scheduled for January 1983.

Tracking and Data Relay Satellite System services are being procured through a long-term service contract from Space Communications Company (SCC). SCC is a partnership of subsidiaries of Western Union, Continental Telephone, and Fairchild Industries. TRW and Harris Electronic Systems Division are major development subcontractors to Space Communications Company. Under the terms of the service contract, SCC will provide the Tracking and Data Relay Satellite System services to NASA for a ten-year period.

The program development phase is being financed through loans from the Federal Financing Bank (FFB). FFB loans are extended to SCC under the terms of a SCC-FFB loan agreement and note. NASA, as an assignee to the FFB note, is responsible for making loan repayments directly to the FFB when the funds are authorized and appropriated by the Congress.

Funds requested for fiscal year 1983 are to initiate repayment of the construction period FFB loan. In addition, funds are requested to make operations and award fee payments to Space Communications Company for the Tracking and Data Relay Satellite System provided, and to provide support to the NASA Tracking and Data Relay Satellite System project management staff in the areas of systems engineering and operations planning.

CONSTRUCTION OF FACILITIES, $100,000,000

The Construction of Facilities (CoF) authorization provides for contractual services for repair, rehabilitation and modification of existing facilities; the construction of new facilities; the acquisition of related facility equipment; the design of facilities projects and advance planning related to future facilities needs.

The funds requested for 1983 provide for: the continuation of prior year's endeavors in meeting the facilities requirements for the Space Shuttle; Space Shuttle Payload support operations; modification of aeronautical research and development facilities; repair, rehabilitation, and modification of other facilities to maintain, upgrade and improve the usefulness of the NASA physical plant; minor construction of new facilities; and facility planning and design activities.

The projects and amounts in the budget estimate reflect Space Shuttle and Space Shuttle Payload requirements that are time sensitive to meet specific milestones. Other program requirements for 1983 include the construction of a data analysis facility at the Ames' Dryden Flight Research Facility; rehabilitation and modification of utility systems at the Goddard Space Flight Center and rehabilitation of the Airfield at Goddard's Wallops Flight Center; modifications to the transonic dynamics tunnel and modifications to the 4- by 7-meter low speed tunnel at the Langley Research Center; and, modifications of the 450 PSI air system and modification of rocket engine test facility for altitude testing at the Lewis Research Center.

The FY 1983 program continues to meet the objectives of preserving and enhancing the capabilities and usefulness of existing facilities and to ensure safe economical and efficient use of the NASA physical plant. This request continues the necessary rehabilitation and modification program as in prior years and continues a repair program. The purpose of the repair program is to restore facilities to a condition substantially equivalent to their originally designed capability. The minor construction program continues to provide a means to accomplish smaller facility projects which accommodate changes in technical and institutional requirements. This program also includes projects which continue NASA efforts to reduce the consumption of energy.

Funds requested for facility planning and design cover advance planning and design requirements for potential future projects, master planning, facilities studies, engineering reports and studies and the preparation of facility project design drawings and bid specifications.

CONSTRUCTION OF FACILITIES

Summary

Projects	Authorization FY 1983	Page No.
1. Space Shuttle facilities at various locations, as follows:		
A. Modifications to solid rocket booster refurbishment and subassembly facilities; Kennedy Space Center	$1,700,000	
B. Modifications of manufacturing and final assembly facilities for external tanks; Michoud Assembly Facility	17,845,000	
C. Minor shuttle—unique projects; various locations	1,860,000	
2. Rehabilitation and modification for payload ground support operations; Kennedy Space Center	1,740,000	
3. Rehabilitation and modification of utility systems; Goddard Space Flight Center	2,840,000	
4. Rehabilitation of airfield; Wallops Flight Center	2,150,000	
5. Construction of data analysis facility; Dryden Flight Research Facility	4,500,000	
6. Modifications to the 4- by 7-meter low-speed tunnel (1212–C); Langley Research Center	7,200,000	
7. Modifications to upgrade the Transonic Dynamics Tunnel (648); Langley Research Center	9,000,000	
8. Modification of rocket engine test facility for altitude testing; Lewis Research Center	995,000	
9. Modification of 450 psi air system in engine research building; Lewis Research Center	2,920,000	

Projects	Authorization FY 1983	Page No.
10. Repairs of facilities at various locations	15,000,000	
11. Rehabilitation and modification of facilities at various locations	20,000,000	
12. Minor construction of new facilities and additions to existing facilities at various locations	4,000,000	
13. Facility planning and design	8,250,000	
Total construction at facilities	100,000,000	

1. SPACE SHUTTLE FACILITIES AT VARIOUS LOCATIONS, $21,405,000

A. MODIFICATIONS TO SOLID ROCKET BOOSTER REFURBISHMENT AND SUBASSEMBLY FACILITIES; KENNEDY SPACE CENTER, $1,700,000

This project provides for modifications to facilities used in the refurbishment and subassembly of solid rocket booster (SRB) forward and aft skirts at the Kennedy Space Center (KSC). These facilities include the Vehicle Assembly Building (VAB) low bay, the Hypergol Maintenance Facility (HMF) and Hangar N; which sequentially process forward and aft skirts to ready them for subsequent flights.

The first modifications to the VAB low bay and to the HMF were programmed in the FY 1976 budget and were intended to provide the initial operational capability. It was recognized from the outset that additional modifications would be necessary once refurbishment procedures were refined and matured. Experience from processing STS–1 indicates that both the VAB low bay and the HMF SRB operations can support only eight flights per year. In the low bay, the present curing cells block efficient access to the spray booths, and additional curing cells are needed. To add new curing cells and to eliminate the congestion near the spray booths, a partial rearrangement of the low bay is required. Similarly, in the hmf, tvc processing would be greatly enhanced by the rearrangement of interior floor space, including the relocation of some shop areas to Hangar N

B. MODIFICATION OF MANUFACTURING AND FINAL ASSEMBLY FACILITIES FOR EXTERNAL TANKS; MICHOUD ASSEMBLY FACILITY, $17,845,000

This project continues work funded in Fiscal Year 1982 and prior years for modification of manufacturing and final assembly facilities at the Michoud Assembly Facility (MAF) for the Space Shuttle External Tank (ET) production. The ET is the component of the Space Shuttle that supplies propellants to the Orbiter's main engines. Each ET consists of three major components: a liquid oxygen (LO_2) tank, an intertank and a liquid hydrogen (LH_2) tank. The facility modifications at MAF are required to provide capability for fabrication and assembly, testing and cleaning, application of a thermal protection system (TPS) and major component assembly of the ET. The tank is also equipped with plumbing and electrical systems, and then checked/accepted prior to shipment to the launch site for mating with the Orbiter and Solid Rocket Boosters.

Prior years resources provided phased modifications to the Main Manufacturing Building, Building 103; the Vertical Assembly Building (VAB), Building 110; and the Final Acceptance and Checkout Building, Building 420. Included were construction of a high bay facility, Building 114, to apply thermal protection system (TPS) coating to the LO_2 tank and the intertank; a facility for cleaning, priming and applying ablator to the LH_2 tank, Building 131; and a pneumatic proof test facility for the LH_2 tank, Building 451.

This project provides for the construction of two environmentally controlled spray cells (K&L) for TPS application on the LO_2 tank and intertank, installation of a 75-ton crane in the VAB, and general modifications in the Manufacturing Building 103 to improve production flow and productivity. The work in Building 103 includes providing a production aisle through the main manufacturing plant, upgrading an overhead crane system located in the LH_2 tank weld area and providing a controlled environment area in the ET final assembly area. The following work is included:

TPS Spray Cells K&L.—Two cells each 41 feet (12.3 meters) in diameter and 85 feet (25.5 meters) high will be constructed in Building 114 (Figure 3). The walls will be structural steel frame with gypsum wall board. Each cell will be provided with a 32-foot (9.6 meter) wide door, personnel access doors, platforms and ladders. Utilities include plant air, breathing air, gaseous nitrogen, fire suppression/detection devices, exhaust system, explosion proof electrical fixtures, and sodium vapor lighting. A controlled cell environment from 150°F to 60°F with relative humidity from 70% maximum to 30% minimum will be provided. Tank heating systems will provide heating temperatures of 140°F to 240°F and cooldown temperatures of 55°F-60°F.

Additional 75-Ton Crane.—New rail-mounted, low profile 75-ton crane will be installed below the existing 75-ton crane in Building 110 (Figure 4). The crane will travel in an east/west direction and will be cab and radio controlled. A dual crane safety system, emergency stops and a motor control center are also included in this project.

Production Flow Aisle.—An east/west aisle, 45 feet (13.7 meters) wide will be provided through the entire length of the Manufacture Plant Building 103 (Figure 5). Work includes relocation of an existing X-ray laboratory, constructing open doorways on three interior walls, raising overhead cranes and rails, and rerouting existing utilities, ducts, and control panels. At the east end of the aisle, the exterior wall of the plant will be penetrated and a new door, apron and driveway will be provided. Also a 5-ton crane system will be provided over the east end of the aisle for movement of LO_2 and LH_2 dome components.

LH_2 Tank Bridge and Hoist Modification.—The work includes increasing the rated capacity of four existing 10-ton bridge cranes located in the LH_2 tank welding area in the Main Manufacturing Plant, Building 103 (Figure 6). Two bridge cranes will be uprated to 15 tons and the other two bridge cranes to 20 tons. Local structural

strengthening and truss modifications will also be accomplished to support the increased capacity of the cranes. Four 7½-ton hoists will also be provided.

Environmental Control for Final Assembly Positions.—This project provides for partitioning the four final assembly positions into separate environmental chambers in the Main Manufacturing Plant, Building 103 (Figure 7). The work includes installing fabric type walls with personnel access doors to allow movement from position to position and providing an environmental system capable of maintaining each position at a dew point of 59°F±5°F at a temperature of 80°F±5°F. The existing monorail system in positions #1 and #2 will also be replaced with a bridge crane system similar to positions #3 and #4.

C. MINOR SHUTTLE—UNIQUE PROJECTS; VARIOUS LOCATIONS—$1,860,000

The purpose of this project is to provide minor rehabilitation, modification and construction of facilities necessary for support of the Space Shuttle Program at various NASA field installations. Included in this funding request are facility projects estimated to cost less than $500,000 each. These projects respond to unique requirements of the Space Shuttle Program and are needed to achieve initial operational capability or to meet the program milestones. The following projects are included:

JOHNSON SPACE CENTER (JSC)

Modifications to Building 30 for Shuttle Operations

This project is Phase V of a multiyear program to reconfigure the Mission Control Center, Building 30, for the Shuttle operations era. The Data Reduction Complex (DRC) is currently designated to meet general onsite operational requirements and specific Shuttle Avionics Integration Laboratory and Orbital Flight Test requirments. This project will permit the installation of necessary equipment to meet the increased data reduction requirements in the 1984-87 period resulting from reconfiguration of the Mission Operations Wing (MOW) to support multiple Shuttle flights and DOD operations. This project provides for the reconfiguration of the DRC by: removal/relocation of walls and doors; modifications to the electrical power distribution system; relocation of computer equipment; installation of new computer equipment; and modifications to the closed-loop coolant system. Modifications to existing lighting, power distribution, air-conditioning and fire detection/suppression systems will also be made.

Modifications to the 11-Foot Chamber Complex, Building 7

The Modifications to the 11-Foot Chamber Complex are required to provide a man-rated facility to simulate the operational configurations of the Orbiter cabin and various airlock/tunnel adapter arrangements. This change will allow evaluation of environmental control systems, extravehicular system hardware and associated procedures under simulated flight conditions. This added capability is essential to adequately evaluate potential Orbiter enhancements and their resulting effect upon operations, to conduct crew training and evaluate crew interfaces for new operational techniques, and to conduct real time/postflight anomaly investigations.

The work includes modifications to an existing airlock to simulate the Shuttle transfer tunnel and modifications to the Environmental Control Life Support Subsystem (ECLSS) Test Article for reduced pressure and oxygen/enriched atmosphere operation. Airlock modifications include the connection of the airlock to the Airlock Test Article cabin.

KENNEDY SPACE CENTER (KSC)

Construction of Component Cleaning Facility, LC-39

Certain components of the mobile launcher platform and of the various systems at the launch pad are routinely removed for cleaning and other maintenance activities. These functions are presently performed in the open, on the paved area adjacent to a POL storage facility, Building K7-612. Cleaning and processing of these components is inefficient due to exposure to the elements. This project provides for a 40-foot by 60-foot (12 meter by 18 meter) pre-engineered metal building, a concrete foundation and the extension of electrical and utility lines to yield an enclosed facility in which to more appropriately perform component cleaning and staging.

Installation of Permanent MSBLS Cables, White Sands Missile Range

At the White Sands Missile Range, the Northrup Flight Strip has been used for astronaut training in the Shuttle Training Aircraft and is also designated as a backup Orbiter landing site. To support both requirements, Microwave Scanning Beam Landing System (MSBLS) cables have been installed. These cables were originally installed above ground in a temporary fashion as it was not certain how long they would be required. It has now been determined that this landing site will be used on a continuing basis for training, as well as for an Orbiter contingency landing site. The above ground cables have become weather-worn and must be replaced.

Modifications for Flight Kit Storage, Building M7-505

Flight kits are items of flight hardware which are installed in the orbiter for a specific flight and removed after landing. They extend the capability of systems on the orbiter and provide an orbiter interface to the payloads. There are approximately 35 different types of flight kits totaling 90 individual pieces of hardware. Examples of flight kits include the remote manipulator system (RMS), the manned maneuvering unit (MMU), Spacelab utility kits, and rescuse kits. Because these items are to be used on an intermittent basis, adequate ground storage space must be provided. This project will modify approximately 10,000 square feet (900 square meters) of open space in Building M7-505 (KSC Industrial Area) to provide a dedicated storage area for these high value flight kits.

Modifications to Power Distribution System, Pad B

The primary source of electrical power at Pad B is the 60-hertz distribution system. This system was originally installed during the Apollo program and has remained substantially unaltered since that time. Continual exposure to the salt air environment has caused the need for a general refurbishment of this system. The work includes repairing or replacing, as appropriate, the major electrical components servicing the liquid oxygen area, the gaseous hydrogen area, the switching stations, the transformers and the camera pads.

2. REHABILITATION AND MODIFICATION FOR PAYLOAD GROUND SUPPORT OPERATIONS; KENNEDY SPACE CENTER, $1,740,000

This project continues construction and rehabilitation/modification of facilities necessary to support Space Shuttle payload ground operations at the NASA launch site, Kennedy Space Center (KSC), begun with prior year resources. This year's request provides: Modifications to the fire suppression/detection/alarm systems and to the AC power system at both the Delta Spin Test Facility (DSTF) and the Explosive Safe Area-60 (ESA-60). Modifications to the Operations and Checkout (O&C) Building for human life science experiments and for payload processing monitoring and Modifications to the communication cabling between KSC and Cape Canaveral Air Force Station (CCAFS).

At the DSTF and ESA-60, the following modifications will be made to fire detection/alarm/suppression systems and to the AC power system: replacement of existing sprinkler heads with deluge high density-type nozzles; rewiring of all manual pull alarm stations; addition of water deluge remote control activation stations; replacement of power cable seals; and installation of exit lights at all exterior doors.

In the O&C Building, 450 data transmission and control cables of various sizes will be provided to connect the payload user room area of the fourth floor with the workstands, signal acquisition room and lab areas on the first floor. Approximately 5,000 square feet (450 square meters) on the first floor of this building will be modified to house human life science experiment equipment. Modifications consist primarily of rerouting existing HVAC and electrical lines.

To connect the main CCAFS and KSC communication centers, approximately six miles (ten kilometers) of data transmission cable will be installed in existing underground ducting. The project includes cable procurement, installation and all required splicing.

3. REHABILITATION AND MODIFICATION OF UTILITY SYSTEMS; GODDARD SPACE FLIGHT CENTER, $2,840,000

These resources will provide for the rehabilitation and modification of utility systems at the Goddard Space Flight Center (GSFC). The chilled water system in the Central Heating and Refrigeration Plant, Building 24, will be rehabilitated through replacement of four chillers and cooling tower "A". The present equipment is approximately 20 years old, unreliable, inefficient, and lacking in required capacity. Replacement of this portion of the chilled water system is urgently needed to insure reliable environmental conditions for critical real-time spacecraft and data processing operations.

This project provides for the rehabilitation and modification of the Center's chilled water system in the Central Heating and Refrigeration Plant, Building 24. The work will include the removal of four old chillers and the installation of one electric driven chiller with a capacity of 3,000 tons (10,541 kilowatts). The installation includes; modification of supply and return water piping and valves with thermal insulation; the strengthening of the foundation and installation of floor supports for piping and other equipment; and electrical modifications to include new power supply and controls with ducts and conduits for cables and wiring.

Cooling tower "A" will be rehabilitated and restored to service. Part of this rehabilitation will be the replacement of existing condenser water pumps and fans. An equalizing line and crossover piping will be installed to connect cooling towers "A" and "B" to allow either or both towers to support both new and existing chillers.

4. REHABILITATION OF AIRFIELD; WALLOPS FLIGHT CENTER, $2,150,000

This project rehabilitates the airfield pavements at Wallops Flight Center to assure continuing and reliable operational support for aeronautical research programs. The work includes resurfacing portions of all three runways and a primary taxiway, correction of drainage problems on runway 10-28, and repair of surface spalls, cracked corners and open joints in runway 4-22. These airfield pavements are 26 years old. They require major rehabilitation and repair to prevent further degradation which would require extensive replacement of pavements and subbase. The work needs to be accomplished now to enhance aircraft safety by minimizing foreign object damage to engines and to reduce airfield maintenance and repair costs. The Wallops airfield supports a wide variety of aeronautical research activities such as terminal area operations including landings and takeoffs, general aviation aircraft spin testing, noise propagation, water spray ingestion, storm hazards, antiskid braking systems, and flight evaluation of advanced avionics systems.

Runway 17-35 is used for instrument landings during inclement weather. It also provides for straight-in landings from the Snow Hill Very High Frequency Omni-Directional Range Station (VOR). A hazardous cargo loading ramp is located adjacent to the runway for loading and unloading rocket motors in support of sounding rocket programs.

Many of the aeronautical test programs require the unique capabilities of a single runway while others require multidirectional runway capability because of aircraft crosswind limitations or to support crosswind landing and takeoff research. Spin research aircraft including the AA-1 Yankee, the C-25 Sundowner, the C-172K Cessna, as well as the high altitude U-2 Earth observations research aircraft are examples of such wind sensitive aircraft. The F-18 aircraft test program for the Department of Defense requires the arresting gear installed on runways 10-28 and 4-22.

This project will restore the integrity of the airfield paving and maintain the capability for providing reliable support for flight research activities. This NASA research airfield is expected to remain fully operational for the foreseeable future.

5. CONSTRUCTION OF DATA ANALYSIS FACILITY; DRYDEN FLIGHT RESEARCH FACILITY, $4,500,000

This project provides for the construction of a Data Analysis Facility at the Dryden Flight Research Facility to consolidate data automation activities and house new computers and ancillary equipment. This facility is required to eliminate serious deficiencies in computer operations space requirements, security and safety problems, fire protection inadequacies, support space, and dispersed operating locations. The Data Analysis Facility includes an operations area, service area, tape storage and office space. The existing fragmented computer operations in the Aircraft Construction and Modification Hanger, Building 4801, will be phased out and personnel, now housed in substandard trailers, will be relocated into the vacated space.

This project provides for the construction of a two-story concrete masonry building approximately 22,000 square feet (2,044 square meters) in area. The first floor will enclose approximately 11,000 square feet (1,022 square meters) and the second floor will contain approximately 11,000 square feet (1,022 square meters). The foundation and structural framing will be of reinforced concrete. Construction will include all utilities, power distribution of 480/208/110 volts, and lighting levels of approximately 50-foot candles (538 lumens/square meter) in office and laboratory areas; heating, ventilating, and air-conditioning (HVAC); plumbing, and fire protection.

The first floor will house the programmers, technical support functions, and mechanical equipment. The second floor will provide approximately 6,500 square feet (604 square meters) of raised floor for new computers and associated equipment. The remaining area will provide space for computer maintenance and the storage of magnetic tapes.

6. MODIFICATIONS TO THE 4- BY 7-METER LOW SPEED TUNNEL (1212C); LANGLEY RESEARCH CENTER, $7,200,000

The purpose of this project is to increase the operational efficiency and productivity of the 4- by 7-meter low speed tunnel at Langley Research Center (LaRC) which has operated on a 2-shift bases since it was completed in 1970. A constant demand for research testing in the tunnel has resulted in a two-year backlog. This project will produce significant increases in operational efficiency and productivity. As a by-product, test time will be created for previously deferred, high risk ventures that were victims of the backlog. This project includes doubling the size of the model preparation area, building two new model support carts, developing a rotor test area for helicopter model assembly and hover testing, enlarging the tunnel control room, providing a laser velocimeter (LV) laboratory providing flow improvement in the tunnel circuit, and rehabilitating support areas in Building 1212.

This project provides for the modification of the 4- by 7-meter low speed tunnel Building 1212C and the rehabilitation of support areas in building 1212. A 7,000-square foot (650 square meter) addition including a 2,400-square foot (223 square meter) mezzanine will be constructed adjacent to Building 2112C. This addition will contain a model preparation area, tunnel control room, and technician support area. An LV lab of 875 square feet (82 square meters) will also be constructed. Other elements of the project include the construction of two new model support carts, the modification to an existing cart, and the development of a rotor test area for helicopter model assembly and hover testing. Tunnel modifications for flow quality improvements include the addition of screens and vortex generators. Rehabilitation of offices and restrooms, window, lights, power distribution system, floor and wall covernings, and ceilings as required will be performed in Building 1212. The heating, ventilating, and air-conditioning (HVAC) system will also be rehabilitated.

7. MODIFICATIONS TO UPGRADE THE TRANSONIC DYNAMICS TUNNEL (648); LANGLEY RESEARCH CENTER, $9,000,000

The Langley Research Center's (LaRC) Transonic Dynamics Tunnel (TDT) embodies unique features that make it a national resource in the field of aeroelasticity research. It is used for verifying flutter and other aeroelastic characteristics of high speed aircraft designs; for research on active flutter controls and rotorcraft aeroelasticity; for flutter, buffet and ground wind loads testing of the Space Shuttle and other space and launch vehicles; and for confirmation of unsteady transonic flow theory. These modifications will increase the test medium density range of this tunnel by 50 percent and enable scaling of key aeroelastic parameters for current and anticipated future aircraft designs. This will be achieved by increasing the power of the drive motor by 50 percent, increasing the tunnel circuit cooling, upgrading the electrical power and control systems and modifying the tunnel fan.

This project provides for rewinding of the 20,000-horsepower (1,500 kilowatt), two-speed electric drive motor to achieve a fan drive of approximately 30,000 horsepower (2,200 kilowatt). Additional tunnel circuit cooling will be provided to accommodate the increased tunnel drive power by installing a cooling coil adjacent to the existing tunnel cooling coil. An existing cooling tower will be modified to provide the additional cooling water required. The 6,600-volt power supply will be modified by installing new circuit breakers and new power cables to the drive motor. The tunnel controls will be updated to provide for smooth, stepless speed control of the repowered drive system. The existing liquid rheostat will be replaced with one of sufficient size to accommodate the increased power requirements. All fan blades and blade holders will be replaced with new units designed for the increased tunnel power.

The high pressure freon, hydraulic, and air systems will be repaired. This will include: (1) the repair of defective welds; (2) replacement of piping and piping components which are not rated for the working pressures; (3) replacement of worn flexible hoses on hydraulic systems; (4) installation of piping supports; (5) replacement of leaking valves; and (6) rerouting of piping to reduce stresses.

8. MODIFICATIONS OF ROCKET ENGINE TEST FACILITY FOR ALTITUDE TESTING; LEWIS RESEARCH CENTER, $995,000

This project provides modifications to the Rocket Engine Test Facility (202) at the Lewis Research Center for space simulation testing of low thrust chemical rocket engines. Chemical rocket propulsion research and technology cannot be satisfactorily conducted without this capability for space simulation testing. Current programs require altitude simulation testing in calendar year 1984 of low thrust chemical propulsion systems developed for orbit transfer of large space structures. For this technology development testing, the Rocket Engine Test Facility (RETF) must be modified for altitude testing by adding an altitude exhaust system for space simulation. This facility as currently configured has capability for sea level testing only.

There are two major aspects to the RETF modifications. The first is to structurally mofify the test stand and support systems to accommodate the rocket engines that are being developed. The second aspect is to make necessary modifications to this test facility so that the chamber in which the rocket is fired simulates the space environment (low atmospheric pressures up to 180,000 feet).

To accommodate the size, shape and thrust reaction of the rocket engine undergoing testing, the existing test stand and foundations must be modified for the new loads and be reconfigured to support test articles. Also, the facility must be modified to support the various components of the exhaust system which is specially designed to permit safe release of the rocket products of combustion while maintaining the low pressure test environment in the chamber.

The components required for this are the test engine capsule, the diffuser, the spray cooler and the ejector. The test engine capsule serves as the test chamber which is evacuated to the low pressure simulating the high altitude space environment. The products of combustion from the test rocket engine flow from the capsule into the water jacket cooled diffuser and then into the spray cooler where the exhaust is quenched and scrubbed clean prior to ejection. To permit test setup, checkout and general accessibility, the capsule and diffuser will be mounted on tracks.

In addition to these foundations, supports and the components of the exhaust system, this project also provides the required controls and instrumentation, fire protection, and the associated walkways, platforms and ladders.

9. MODIFICATION TO 450 PSI AIR SYSTEM IN ENGINE RESEARCH BUILDING; LEWIS RESEARCH CENTER, $2,920,000

This project provides for the acquisition and installation of a new 450-pounds per square inch (310 Newtons per square centimeter) air compressor in Engine Research Building 5 with controls, instruments, associated equipment and accessories (Figure 1). This new compressor will replace a 30-year-old existing 450 psi compressor as the primary unit for the 450 psi air system which is a vital component part of the Lewis Central Air System. The existing 450 psi compressor will be retained as backup unit and be used in parallel with the new compressor to provide compressed air flows that exceed the capacity of the present system. The new compressor will be capable of supplying compressed air up to a maximum of 38 pounds per second (17.3 kilograms per second). Parallel operation with the old compressor will provide a total flow up to 76 pounds per second (34.6 kilograms per second).

A new 450 psi compressor will be installed as part of the 450 psi (310 Newtons per square centimeter) air system. The proposed location for this new compressor is adjacent to the existing 450 psi machinery (Figure 2). This location will require minimum piping runs and will result in a very effective integration of existing capability and new system. The machine will be fed from existing 125 psi air systems and deliver 450 psi air to the test locations (Figure 3). The new machine will be installed in parallel electrically and mechanically with the old machine, and the installation will include all necessary valves, cooling, piping, controls and instrumentation systems.

10. REPAIR OF FACILITIES; VARIOUS LOCATIONS, $15,000,000

A major portion of the Agency's buildings exceed 15 years in age, and increases in repair requirements are to be expected. Maintenance and repair costs for mechanical and electrical systems in a typical building are almost three times higher during the 16- to 30-year period of a building's life than they are during the initial 15 years of beneficial occupancy. At about the 15-year point, many electrical and mechanical components reach the end of their serviceable or economic life and should be replaced in the interest of long-term economy. Continued piecemeal repair of these components usually requires more resources in the long run than replacement after the end of the economic life of the original components. This condition is now being encountered at locations such as Goddard Space Flight Center (GSFC) and Johnson Space Center (JSC). The age of other portions of the NASA plant, such as facilities at Langley research Center (LaRC) and Lewis Research Center (LRRC), highlight the need for an aggressive repair program. Some 75 percent of the physical plant is in the 16- to 30-year old category.

The major thrust of this repair program, as well as the rehabilitation and modification program, is to preserve the Agency's $7.0 billion (as of September 30, 1981) physical plant. The major distinction between these classes of work is whether or not the intended work is to bring the facility and its components to a condition substantially equivalent to its designed capacity, efficency, and capabilities. If such is the case, the work is classified as repair. An analysis of each of the projects for which funds are requested indicates that this work must be addressed and progressively accomplished. Otherwise, risks are increased and future costs of the specific work will be greater. More importantly, there will be increased breakdowns and costly emergency repairs required.

This program includes only facility repair work having an estimated cost not in excess of $500,000 per project. The work is of such a nature and magnitude that it cannot be accomplished by routine day-to-day facility maintenance and repair activities, or by related routine facility work efforts that are provided for in other than CoF estimates. Each repair project, estimated to cost more than $500,000, is reflected elsewhere as a separate major line item project.

PROJECT DESCRIPTION

Proposed repair projects for FY 1983 totaling $15,000,000 are described under "Project Cost Estimate." Projects estimated to cost not in excess of $150,000 have not been individually described or identified by Center, and the total estimate for these projects is $1,260,000. This repair program has been distilled from requests for FY 1983 exceeding $23,770,000, and thus represents a modest request in relation to the continuing backlog of this type of work. Based on relative urgency and expected return on investment, the projects which comprise this request are of the highest priority. Deferral of this mission-essential work would adversely impact the availability of critical facilities and program schedules.

During the course of the year, it is recognized that some rearrangement of priority may be necessary. This may force a change in some of the items to be accomplished. Any such change, will be accomplished within available resources. The following broad categories of work are described further in the estimate.

Project Cost Estimates

Utility Systems	$5,285,000
General Purpose Buildings	755,000
Technical Building/Structures	2,840,000
Pavements and Drainage	2,230,000
Building Exteriors and Roofs	3,890,000
Total	15,000,000

Summary of Project Amounts by Location

Ames Research Center	$1,415,000
Dryden Flight Research Facility	200,000
Goddard Space Flight Center	1,345,000
Jet Propulsion Laboratory	1,250,000
Johnson Space Center	1,390,000
Kennedy Space Center	780,000
Langley Research Center	1,195,000
Lewis Research Center	1,275,000
Marshall Space Flight Center	1,570,000
Michoud Assembly Facility	905,000
National Space Technology Laboratories	1,250,000
Wallops Flight Center	1,165,000
Miscellaneous Projects Not Exceeding $150,000 Each	1,260,000
Total	15,000,000

11. REHABILITATION AND MODIFICATION OF FACILITIES AT VARIOUS LOCATIONS, $20,000,000

Based on the initial investment costs, the existing NASA physical plant totals approximately $7.0 billion (September 30, 1981). A continuing program of rehabilitation and modification of these facilities is required to:

(a) Protect the capital investment in these facilities by minimizing the cumulative effects of wear and deterioration.

(b) Ensure that these facilities are continuously available and that they operate at peak efficiency.

(c) Improve the capabilities and usefulness of these facilities and thereby mitigate the effects of obsolescence.

(d) Provide a better and safer environment for all personnel.

(e) Provide significant reductions in energy consumption through the initiation of energy conservation projects including improved utility control systems.

This program includes only facility rehabilitation and modification work having an estimated cost not in excess of $500,000. The work is of such a nature and magnitude that it cannot be accomplished by routine day-to-day facility maintenance or by related routine facility work efforts that are provided for in other than CoF estimates. Rehabilitation and modification work estimated to cost more than $500,000 is reflected as a separate major CoF line item project.

The total program has been distilled from requests of approximately $33,000,000 and represents only a modest request in relation to the backlog of this type of work. Based on relative urgency and expected return on investment, the projects which comprise this request are the highest priority requirements. Deferral of this mission-essential work would adversely impact the availability of critical facilities, program schedules, and energy conservation objectives.

During the course of the year, some rearrangement of priorities may be necessary. This may force a change in some of the items to be accomplished. Any such change will be accomplished within available resources.

Project Cost Estimates

Utility Systems	$5,825,000
Fire Detection/Protection Systems	730,000
General Purpose Buildings	3,580,000
Technical Buildings/Structures	9,000,000
Pavements and Drainage	165,000
Building Exteriors and Roofs	700,000
Total	20,000,000

Summary of Project Amounts by Location

Ames Research Center	$1,760,000
Dryden Flight Research Facility	850,000
Goddard Space Flight Center	1,740,000
Jet Propulsion Laboratory	1,915,000
Johnson Space Center	1,830,000
Kennedy Space Center	740,000
Langley Research Center	1,640,000
Lewis Research Center	1,540,000
Marshall Space Flight Center	3,010,000
Michoud Assembly Facility	1,145,000
National Space Technology Laboratories	[illegible]
Wallops Flight Center	[illegible]
Various Locations	650,000
Miscellaneous Projects Not Exceeding $150,000 Each	930,000
Total	20,000,000

12. MINOR CONSTRUC[illegible]FACILITIES AND ADDITIONS TO EXISTING FACILITIES AT VARIOUS LOCATIONS, $4,000,000

The configuration of NASA's physical plant necessarily must respond to changes in utilization and adaptations required by changes in technology or in mission needs. Demands are generated by reseach, development, test, and similar activities.

Included in the FY 1983 minor construction program are those facility projects for institutional or technical facility needs which could be fully identified at the time of submission of this budget estimate. Items of work totalling $4,000,000 are included in this resource request and have been distilled from a list totalling over $7,000,000. Projects were selected on the basis of the relative urgency of each item and the expected return on the investment. During the course of the year, rearrangement of priorities may require changes in some of the items to be accomplished. Such changes will be accommodated within the resources allocated.

These projects represent requirements that must be met in this time frame to support institutional needs and programmatic objectives.

Cost Distribution by Work Category

Utility Systems	$245,000
General Purpose Buildings	2,000,000
Technical Buildings/Structures	1,755,000
Total	4,000,000

Summary of Project Amounts by Location

Ames Research Center	$520,000
Dryden Flight Research Facility	555,000
Goddard Space Flight Center	460,000
Jet Propulsion Laboratory	700,000
Langley Research Center	615,000
Lewis Research Center	200,000
National Space Technology Laboratories	480,000
Wallops Flight Center	470,000
Total	4,000,000

13. FACILITY PLANNING AND DESIGN, $8,250,000

Regular Requirements	$6,350,000
Other Requirements	1,900,000
Total	8,250,000

The funds requested in this estimate are required to provide for the following advance planning and design activities related to facilities activities and projects:

[redacted] The accomplishment of necessary development and master p ng for field installations and, where not otherwise provided provision of continuing engineering support and special enginee ng management and other services.

(b) [redacted] cost estimates, and design and

(c) The preparation of final construction plans, specifications, and associated cost estimates and schedules required to implement constructin projects.

(d) The accomplishment of facilities siting and other investigations, studies and reports.

Regular requirements encompass the basic purposes outlined above. The "other requirements," while also in support of these purposes, cover those special needs related to large, complex projects or specific programs considered to represent high potential future construction requirements and for which early definition is essential. The large projects require more planning and longer lead time than is normally involved. Much of this planning must be completed prior to inclusion of the project in a budget request.

REGULAR REQUIREMENTS

Master Planning	$100,000
Sustaining Engineering Support	450,000
Preliminary Engineering Reports and Related Special Engineering Support	2,100,000
Final Design	3,700,000
Total	6,350,000

Master Planning

Provides for the updating and further development of existing master plans for the field installations, including facility studies and site investigations. Documentation will define facility parameters within which subsequent engineering efforts will be based for future development. Provides for the documentation of existing plans where actions or deviations from previous plans have not been recorded for the various field installations.

Master plans at the various field installations are generally updated at cyclic 4-year intervals. Approximately one-fourth of the field installations are involved in any one fiscal year, keeping the level of effort relatively modest and constant. These plans provide for the orderly consideration of the allocation, proper arrangement, and efficient correlation of land areas and structures to serve the purpose of the various installations. Representative master planning activity candidates for FY 1982 are:

(1) National Space Technology Laboratories

An update of the facilities inventory base to include new NASA and major tenant facilities as well as the Army Ammunition Plant development.

(2) ARC/Dryden Flight Research Facility (Dryden)

An update of the facilities inventory base to include the installation's role in supporting the Space Shuttle as it enters the operational phase, and emerging Ames Research Center assignment and management objectives.

Sustaining Engineering Support

Provisions for facility studies and specific engineering support continue in importance as evidenced in recent years, and must be given high priority throughout FY 1983. These efforts are important due to the unpredictable cost situation which currently exists and may continue; cost trends in construction materials and fuels; the continuing importance of energy conservation and effficiency; and the operation and maintenance cost for the physical plant. This includes provisions for maintaining a current engineering data base and updated construction specifications for utilization by the various field installations.

The following items are included in the FY 1983 requirements:

(1) Building Research Advisory Board Support

Covers annual support to the Federal Construction Council's (FCC) operations and provides for special studies that the Council will perform throughout FY 1982 to help advance the science and technology of Federal Government building and construction. The FCC is subordinate to the Building Research Advisory Board, National Academy of Sciences, and its activities are supported by several Federal Agencies including NASA.

(2) Utilities Services/Rates Analysis

Provides resources for the availability of continuous services in support of utilities procurement and utilities control systems. This includes, but it not limited to, technical assistance, surveillance, and recommendations with regard to utility rates, contract negotiations, systems operations, and utilities control systems. Because of continuing increases in energy costs, these services are an annual requirement and continue to be essential.

These resources enable the Agency to insure that fair and reasonable rates are charged under its major utility contracts. Essential and valuable technical assistance is provided to our field installations so that effective negotiations can be conducted with utility companies. Several major utility contracts per year require technical assistance as utility contract rates are renewed throughout the Agency.

NASA's significant ongoing investment in utility control and management systems requires a high level of technical maintenance and support. The proper function and operation of the equipment are essential in order to realize the benefits. These resources provide the high technical capabilities needed to maintain the system and insure proper operation and use.

These resources will provide for an updating of our system for forecasting utility costs and rates, so that better and more reliable utility budget requirements can be established. The accuracy and credibility of these forecasts impact the Agency's planning for other resources.

These and other similar utility system services are provided for by these resources in order to insure technical competence and properly manage this function.

(3) Facility Operation and Maintenance Analysis

Provides for continued engineering support for implementing improvements at NASA field installations relative to manpower utilization, work contrl systems, preventive maintenance, facilities management and reporting systems. Improvements will also involve techniques to identify where and how increases in productivity are possible by using earlier, reliable measurement methods. Included in this activity are field surveys to be conducted on a priority basis at selected NASA field installations to evaluate the effectiveness of the operations and maintenance management systems.

(4) Value Engineering Cost Validations and Analyses

Provides for engineering services to improve cost-effectiveness of facility projects by subjecting project design criteria, specifications and working drawings for specific material components and systems to a detailed independent review by engineering specialists in the particular area of involvement. Also provides services necessary to accurately predict and validate facility costs which will aid in resources planning for the various field installations.

(5) Facilities Utilization Analyses

Provides for the analyses of Agency-wide facilities utilization data covering: (1) office and other types of building space; (2) designated major technical facilities; and (3) special studies comparing the utilization of technical facilities which are similar in type or capability, such as wind tunnels. Such analyses provide for: (1) insights into and development of better methods of identifying underutilized facilities; (2) improved techniques of quantifying level of facilities' use; and, (3) actions for improved facilities utilization. Work provides for review of each installation's inventory data base in support of the facilities utilization program. Surveys are necessary to validate the reported data in relation to a specific problem or need, and to assist in providing a credible foundation for plans to improve the utilization of facilities.

(6) Environmental Studies

Provides for the identification of potential environmental problems or the quick resolution of any related controversies at the NASA field installations. These conditions may be brought about by:

New federal, state and local environmental regulations, emission standards and environmental management planning programs that must be considered at various installations;

Changes resulting from new or expanded program activities, new facilities, or major site expansions at NASA installations; and,

Changes that take place in the external environmental conditions at NASA installations.

Early identification of potential environmental problems and quick resolution of these and related controversies at the installations are important. Project managers and facility planners require up-to-date, accurate information to comply with legal and regulatory requirements.

Preliminary Engineering Reports and Related Special Engineering Support

Preliminary Engineering Reports (PER's)	$1,550,000
Related Special Engineering Support	550,000
Total	2,100,000

Preparation of PER's, investigations, and project studies related to proposed facility projects in the FY1985 and FY 1986 Construction of Facilities programs are provided for by this estimate. These reports are required to permit the early and timely development of the most suitable project to meet the stated functional need. Reports provide basic data, cost estimates and schedules relating to future budgetary proposals. This request provides for PER work associated with proposed construction except as provided for in other requirements (paragraph 2) for Shuttle Spacelab/Payload and certain energy conservation initiatives.

The estimated cost of PER support for FY 1985 construction projects is $950,000 which will permit updating of PER's for $35–45 million of construction, and the development of new PERs for an additional $25–30 million of projects.

An additional $600,000 has been included in this line for the completion of new PER's for approximately $25–30 million of construction projects which will be high priority candidates for inclusion in the FY 1986 Construction of Facilities program. The activity associated with FY 1986 will be confined to the most urgent and clear-cut priority candidates.

Investigations and project studies related to proposed facility projects to be included in the subsequent Construction of Facilities programs are provided for by this estimate. Such studies involve documentation and validation of "as built" conditions, survey/study of present condition of such items as roofing and cooling towers, utility plant condition and operational modes, analysis and support of environmental impact assessments and statements, and other like studies. These studies are required to allow for the timely development of projects to meet the stated functional needs and to provide basic data, cost estimates and schedules for related future budgetary proposals.

Final Design

The amount requested will provide for the preparation of designs, plans, drawings, and specifications necessary for the accomplishment of projects other than Space Shuttle, Spacelab, Payloads and certain energy conservation initiatives. Amounts required for those efforts are included under other requirements (paragraph 2). Projects involved are planned for inclusion in FY 1984 and FY 1985 programs. The goal is to obtain better facilities on line earlier at a lower cost.

The request will provide for final design work associated with construction proposed for the FY 1984 Program, estimated to cost $50 to $55 million, and for $10 to $15 million of high potential projects proposed for the FY 1985 program. The amount included for FY 1984 candidates and for residual requirements of this nature which have accumulated for prior years' final design activities is $3,000,000. For FY 1985, $70,000 is included and the supporting rationale is much the same as that set out in the PER estimate.

OTHER REQUIREMENTS

Space Shuttle Facilities Planning and Design	$1,300,000
Payload Facility Planning and Design	600,000
Total	1,900,000

Other facilities planning and design requirements are generated by programs which are large in size and of a complex nature. Those in this particular request are primarily associated with space programs which require a long planning cycle. Early and progressive design work is essential to ultimately ensure the best design, cost estimate and schedule. These programs require planning effort and associated design lead time well beyond that normally associated with general type facility projects. These requirements must be provided for beyond the regular and most recurrent facility planning and design needs.

Space Shuttle Facilities Planning and Design

This requirement is primarily for the preparation of the final design drawings, specifications and associated site investigations required for construction of future Space Shuttle facilities that have been validated. These requirements are related to the requirements for a third module launch platform, facilities for personnel and logistic support of Space Transportation System operations, expanding and improving SRB processing capabilities at Kennedy Space Center, and additional production related facilities to support External Tanks (ET) production at the Michoud Assembly Facility such as ET storage, production optimization and associated supporting facilities.

Payload Facility Planning and Design

The requirement is for the preparation of Preliminary Engineering Reports (PER's), facility site investigations, deisgn of facility projects, and studies to determine facility capabilities required to support the operational phase of the Space Transportation System pertaining to payloads. Included are facilities for the checkout/fueling and spin test of upper stage vehicles or payloads, and also modification of facilities for processing and housing vertical payloads. In addition, facilities projects are forecasted for the logistical and maintenance support of payloads and storage of associated flight and support equipment.

RESEARCH AND PROGRAM MANAGEMENT, $1,168,900,000

SUMMARY OF BUDGET PLAN BY FUNCTION

Personnel and Related Costs	$829,900,000
Travel	24,100,000
Operation of Installation	324,900,000
General reduction	*−10,000,000*
Total	1,168,900,000

The Research and Program Management appropriation funds the performance and management of research, technology and test activities at NASA installations, and the planning, management and support of contractor research and development tasks necessary to meet the Nation's objectives in aeronautical and space research. Objectives of the efforts funded by the Research and Program Management appropriation are to (1) provide the technical and management capability of the civil service staff needed to conduct the full range of programs for which NASA is responsible, (2) maintain facilities and laboratories in a state of operational capability and manage their use in support of research and development programs, and (3) provide effective and efficient technical and administrative support for the research and development programs. For FY 1983, an appropriation of $1,178,900,000 is requested.

More than 21,200 civil service personnel at eight installations and Headquarters are funded by the Research and Program Management appropriation. This civil service workforce is NASA's most important resource and is vital to future space and aeronautics research activities. Seventy percent of the Research and Program Management appropriation is needed to provide for salaries and related costs of this civil service workforce. About two percent is for travel, which is vital to successfully manage the Agency's inhouse and contracted programs. The remaining amount of the Research and Program Management appropriation provides for the research, test and operational facility support, and for related goods and services necessary to successfully operate the NASA installations and to efficiently and effectively accomplish NASA's approved missions.

In 1981 a Headquarters organizational change provided for the NASA field centers to report to the Program Associate Administrator responsible for the major portion of their technical program. Each of the eight NASA installations is assigned certain principal roles of fundamental importance in meeting NASA's overall program goals. These roles reflect the characteristic competence of each installation based on demonstrated capabilities and capacities. They are summarized by the cognizant program office as follows:

Office of Space Transportation Systems

Johnson Space Center: Principal roles are management of the integrated Space Shuttle program and Orbiter development and production; astronaut and mission specialist selection and training; STS Operations including mission planning, operational procedures and flight control; and application of remote sensing to agricultural assessments and other Earth resources uses.

Kennedy Space Center: Principal roles are the launch of Space Shuttle development and test flights; the ground operational phase of the Space Transportation System; and the preparation and launch of payloads on expendable launch vehicles.

Marshall Space Flight Center: Principal roles are management of the Space Shuttle main engine, solid rocket booster and external tank projects; management of NASA's development activities on the Spacelab and Inertial Upper Stage projects; management of large automated spacecraft projects such as the Space Telescope; and experiments in materials processing in space.

National Space Technology Laboratories: Principal roles are the support of Space Shuttle engine development and testing; regional Earth resources research and technology transfer; and support functions for other Government agencies located there.

Office of Space Science and Applications

Goddard Space Flight Center: Principal roles are the development and operation of Earth orbital flight experiments and automated spacecraft to conduct scientific investigations and demonstrate practical applications; the management of the tracking and data acquisition activities for Earth orbital missions; management of the Delta launch vehicle program; management and launch of sounding rockets and balloons; and operation of an instrumented flight range for aeronautical and space research. In 1981, the Wallops Flight Center was consolidated with the designated an operational element and component installation of the Goddard Space Flight Center.

Office of Aeronautics and Space Technology

Ames Research Center: Principal roles are short haul aircraft and rotorcraft research and technology, computational fluid dynamics, planetary probe research, life sciences, aeronautical flight research and testing, as well as providing the primary landing site for Space Shuttle orbital test flights and a contingency landing site for operational missions. In 1981, the Dryden Flight Research Center was consolidated with the Ames Research Center and became the Dryden Flight Research Facility, an operational element and component installation of Ames.

Langley Research Center: Principal roles are long haul aircraft research and technology, emphasizing fuel conservation, safety and environmental effects; aerospace structures technology; environmental quality monitoring by remote sensing; and advanced space systems technology.

Lewis Research Center: Principal roles are aeronautical and space propulsion research and technology; space communications research and technology; space energy systems research and technology; and management of the Centaur expendable launch vehicle program.

The 1983 budget provides the necessary resources to apply these in-house capabilities to appropriate program activities. Detailed data on funding requirements is provided in the section on each installation. A summary description of, and the funding required by functional category, are as follows:

PERSONNEL AND RELATED COSTS

Compensation and Benefits

Compensation:

(a) *Permanent Positions*—This part of Personnel and Related Costs covers the salaries of the full-time permanent civil service workforce and is the largest part of the functional category. As noted above, the 1983 funds will provide for 21,219 full-time permanent civil service employees.

(b) *Other Than Full-Time Permanent Positions*—This category includes the salaries of NASA's non-permanent workforce. Programs such as students participating in cooperative training, summer employment, youth opportunity, and temporary clerical support are covered in this category.

(c) *Reimbursable Detailees*—In accordance with existing agreements, NASA reimburses the parent Federal organizations for the salaries and related costs of persons detailed to NASA.

(d) *Overtime and Other Compensation*—Overtime, holiday, post and night differential and hazardous duty pay are included in this category. Also included are incentive awards for outstanding achievement and superior performance awards.

Benefits:

In addition to compensation, NASA makes an employer's contribution to personnel benefits as authorized and required by law. These benefits include contributions to the Civil Service Retirement Fund, employees' life and health insurance, and social security contributions for non-permanent personnel. Payments for severance pay are made to former employees involuntarily separated through no fault of their own.

Supporting Costs

Transfer of Personnel: Relocation costs, such as the expenses of selling and buying a home, and the movement and storage of household goods are provided under this category.

Office of Personnel Management Services: The Office of Personnel Management is reimbursed for certain activities such as security investigations on new hires, recruitment advertising, and career-maturity surveys.

Personnel Training: Training is provided within the framework of the Government Employees Training Act of 1958. Part of the training costs consist of courses offered by other Government agencies, and the remainder provides for training through nongovernment sources.

TRAVEL

Program Travel

The largest part of travel is for direction, coordination and management of program activities including international programs and activities. The complexity of the programs involved and the geographical distribution of NASA installations and contractors throughout the entire United States impose the requirement for this category of travel. As projects reach the flight stage, support is required for prelaunch activities, including overseas travel to launch and tracking sites. The amount of travel required for projects in the flight phase is significant as it is directly related to the number of systems and subsystems, the number of design reviews, and the number and complexity of the launches and associated ground operations.

Scientific and Technical Development Travel

Travel to scientific and technical meetings and seminars permits employees engaged in research and development to participate at both Government-sponsored and nongovernment-sponsored seminars. This participation allows personnel to benefit from exposure to technological advances which arise outside NASA, as well as allowing personnel to present both accomplishments and problems to their associates and provide for the dissemination of technical results to the U.S. community. Many of the Government-sponsored meetings are working panels convened to solve certain problems for the benefit of the Government.

Management and Operations Travel

Management and operations travel includes travel for the direction and coordination of general management matters and travel by officials to review the status of programs. It includes travel by functional managers in such areas as personnel, financial management and procurement. This category also includes the cost of travel in and around the Installations; travel of unpaid members of research advisory committees; and initial duty station, permanent change of assignment, and other family travel expenses. Payments to interagency motor pools are included in the Operation of Installation Function (Management and Operations subfunction).

OPERATION OF INSTALLATION

FISCAL YEAR 1983 BUDGET PLAN

Facility Services	$179,881,000
Technical Services	55,526,000
Management and Operations	89,493,000
Total	324,900,000

Operation of Installation provides a broad range of services, supplies, and equipment in support of the centers' institutional activities. These are divided into three major subfunctional areas: Facilities Services (the cost of renting real property, maintaining and repairing institutional facilities and equipment, and the cost of custodial services and utilities); Technical Services (the cost of automatic data processing for management activities, and the cost of educational and information programs and technical shops supporting institutional activities); and Management and Operations (the cost of administrative communications, printing, transportation, medical, supply, and related services). A description of each major subfunction follows:

Facilities Services

Rental of Real Property: Rental of real property includes the rental of building space directly by NASA or through the General Services Administration to meet offsite office, warehousing, and other requirements which cannot otherwise be provided in existing buildings at the NASA Installations. Most of the funding is required for rental of the NASA Headquarters complex of buildings in the district of Columbia, and nearby Maryland and Virginia that are either Government-owned or leased for which NASA must provide rental payments to the General Services Administration in accordance with P.L. 92-313. Also included in this item is rental of trailers required to accommodate special short-term needs.

Maintenance and Related Activities: Maintenance and related activities includes the recurring day-to-day maintenance of facilities (grounds, buildings, structures, etc.) and equipment which is accomplished by non-Civil Service personnel. This involves the mowing and care of grassy areas, care of trees and shrubs, elevators, cranes, pressure vessel inspections, painting and protective coatings, general buildings maintenance, and the maintenance of installed mechanical, electrical, and other systems. In addition, this item includes feasibility studies, project design, construction supervision, inspection, and other institutional facility engineering functions. Included also are any applicable costs associated with recurring facility work as well as materials, hardware, and equipment used in facility maintenance activities, whether accomplished by civil service personnel or contractors. In the case of equipment, related maintenance and other services are reflected for office, shop, laboratory and other facilities equipment as well as administrative intercommunications and television monitoring equipment.

Custodial Services: Custodial services include janitorial and building cleaning services, pest control, fire protection services, security services including badging and identification, lock and safe repair, trash and refuse handling, window blinds and light fixture cleaning, and laundry and dry cleaning of facility related items.

Utilities Services: Utilities services include the purchase of utilities such as electricity, natural gas, fuel oil, coal, steam, propane, and other fuel commodities as well as water and sewage treatment services. Also incuded are the related maintenance and operating costs of the utility plants and systems.

Technical Services

Automatic Date Processing:

(a) *Equipment*—This category provides for the lease, purchase and maintenance of general purpose data processing equipment which supports institutional operations at each installation. Excluded is equipment dedicated to specific research or operational systems which is funded from the Research and Development appropriation.

(b) *Operations*—Operations services include programing, computer operations and related services for institutional applications including payroll, financial management, security, maintenance, personnel, logistics, and procurement records and reports.

Scientific and Technical Information and Education Programs:

(a) *Libraries*—The technical libraries are established to provide installation staffs with books, periodicals, technical reports and other documentation.

(b) *Education and Information Programs*—The educational and informational programs provide for the documentation and dissemination of information about the Agency's programs to the general public, the educational community at the elementary and secondary levels, and the mass communications media. Assistance to the mass communications media includes the assembly and exposition of newsworthy material in support requests in the form of press kits, news releases, television and radio information tapes and clips, and feature material.

Shop Support and Services—Shop support and services include general fabrication shops, reliability and quality assurance activities, safety, photographic services, graphics, and audio-visual material.

Management and Operations

Administrative Communications—Included in this category are costs of leased lines, long distance tolls, teletype services, and local telephone service.

Printing and Reproduction—Included in this category are the costs for duplicating, blueprinting, microfilming, and other photographic reproductions. Also included in this category are Government Printing Office printing costs, contractual printing and the related composition and binding operations.

Transportation—Transporation services include the operation and maintenance of all general purpose motor vehicles used by both civil service and support contractor personnel. The cost of movement of supplies and equipment by commercial carriers and payments to interagency motor pools are also in this category.

Installation Common Services—Installation common services include support activities at each installation such as: occupational medicine and environmental health; mail services; supply management; patent services; administrative equipment; office supplies and materials; and postage.

Title II: Landsat Authorization

This title was added to the NASA authorization bill in order to provide authority for the Secretary of Commerce to manage and operate a land remote sensing satellite system, to collect user fees, and to plan for the transfer of future systems to the private sector. The title would also authorize $14,955,000 for carrying out these activities in fiscal year 1983. It is anticipated that the Secretary will delegate these responsibilities to the national Oceanic and Atmospheric Administration (NOAA).

The present agreement between NASA and NOAA is that NOAA will take over operation of LANDSAT D after NASA has launched it and checked it out. The bill would provide the necessary statutory authority for NOAA. Also, there is substantial but not unanimous feeling that the space remote sensing system should be turned over to the private sector. The administration has testified that this transfer shoud be made "as soon as posssible." A related belief is that users of the system should for the most part pay the true cost of the information they obtain from the system. Thus, the provision for user fees.

The Committee is not certain that the transfer to the private sector should be made "as soon as possible" and thus the bill authorizes the Secretary to plan for the transfer "when in the national interest." For national security and international relations reasons, it might be best to retain ownership and operation in the Federal Government indefinitely. In the event that transfer to the private sector should be made, there is the question of timing. Since the Thematic Mapper has never been flown, the private sector may not be willing to take over its operation. The space remote sensing industry is not a large cash-generating industry comparable to the telecommunications industry. Thus there is no analogy between the adoption of communications satellites by the telecommunications industry and the possible adoption of LANDSAT by the fledgling remote sensing industry. The climate in the international scene and in the private sector must therefore influence the timing of any transfer of the space remote sensing system.

SECTIONAL ANALYSIS

A BILL To authorize appropriations to the National Aeronautics and Space Administration for research and development, construction of facilities, and research and program management, and for other purposes

TITLE I

Section 101

Subsections (a), (b), and (c) would authorize to be appropriated to the National Aeronautics and Space Administration funds, in the total amount of $6,612,900,000, as follows: (a) for "Research and development," a total of 11 program line items aggregating the sum of $5,334,000,000; (b) for "Construction of facilities," a total of 13 line items aggregating the sum of $100,000,000; and (c) for "Research and program management," $1,168,900,000. Subsection (c) would also authorize to be appropriated such additional or supplemental amounts as may be necessary for increases in salary, pay, retirement, or other employee benefits authorized by law.

Subsection 101(d) would authorize the use of appropriations for "Research and development" without regard to the provisions of subsection 101(g) for: (1) items of a capital nature (other than the acquisitions of land) required at locations other than NASA installations for the performance of research and development contracts; and (2) grants to nonprofit institutions of higher education, or to nonprofit organizations whose primary purpose is the conduct of scientific research, for purchase or construction of additional research facilities. Title to such facilities shall be vested in the United States unless the Administrator determines that the national program of aeronautical and space activities will best be served by vesting title in any such grantee institution or organization. Moreover, each such grant shall be made under such conditions as the Administrator shall find necessary to insure that the United States will receive benefit therefrom adequate to justify the making of that grant.

In either case, no funds may be used for the construction of a facility in accordance with this subsection, the estimated cost of which, including collateral equipment, exceeds $250,000, unless the Administrator notifies the Speaker of the House, the President of the Senate and the specified committees of the Congress of the nature, location, and estimated cost of such facility.

Subsection 101(e) would provide that, when so specified and to the extent provided in an appropriation act, (1) any amount appropriated for "Research and development" or for "Construction of facilities" may remain available without fiscal year limitation, and (2) contracts for maintenance and operation of facilities, and support services may be entered into under the "Research and program management" appropriation for periods not in excess of twelve months beginning at any time during the fiscal year.

Subsection 101(f) would authorize the use of not to exceed $25,000 of the "Research and program management" appropriation for scientific consultations or extraordinary expenses, including representation and official entertainment expenses, upon the authority of the Administrator, whose determination shall be final and conclusive.

Subsection 101(g) would provide that of the funds appropriated for "Research and development" and "Research and program management", not in excess of $75,000 per project (including collateral equipment) may be used for construction of new facilities and additions to existing facilities, and for repair, rehabilitation, or modification of facilities.

Section 102

Section 102 would authorize upward variations of the sums authorized for the "Construction of facilities" line items (other than facility planning and design) of 10 percent at the discretion of the Administrator or his designee, or 25 percent following a report by the Administrator or his designee to the Committee on Science and Technology of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate on the circumstances of such action, for the purpose of meeting unusual cost variations. However, the total cost of all work authorized under these line items may not exceed the total sum authorized for "Construction of facilities" under subsection 101(b), paragraphs (1) through (12).

Section 103

Section 103 would provide that not more than one-half of 1 percent of the funds appropriated for "Research and development" may be transferred to the "Construction of facilities" appropriation and, when so transferred, together with $10,000,000 of the funds appropriated for "Construction of facilities", shall be available for the construction of facilities and land acquisition at any location if the Administrator determines (1) that such action is necessary because of changes in the aeronautical and space program or new scientific or engineering developments, and (2) that deferral of such action until the next authorization act is enacted would be inconsistent with the interest of the Nation in aeronautical and space activities. However, no such funds may be obligated until 30 days have passed after the Administrator or his designee has transmitted to the Speaker of the House, the President of the Senate and the specified committees of Congress a written report containing a description of the project, its cost, and the reason why such project is necessary in the national interest, or each such committee before the expiration of such 30-day period has notified the Administrator that no objection to the proposed action will be made.

Section 104

Section 104 would provide that, notwithstanding any other provision of this Act—

(1) no amount appropriated pursuant to this Act may be used for any program deleted by the Congress from requests as originally made to either the House Committee on Science and Technology or the Senate Committee on Commerce, Science, and Transportation,

(2) no amount appropriated pursuant to this Act may be used for any program in excess of the amount actually authorized for that particular program by subsections 101(a) and 101(c), and

(3) no amount appropriated pursuant to this Act may be used for any program which has not been presented to or requested of either such committee,

unless (A) a period of 30 days has passed after the receipt by the Speaker of the House, the President of the Senate and each such committee of notice given by the Administrator or his designee containing a full and complete statement of the action proposed to be taken and the facts and circumstances relied upon in support of such proposed action, or (B) each such committee before the expiration of such period has transmitted to the Administrator written notice to the effect that such committee has no objection to the proposed action.

Section 105

Section 105 would express the sense of the Congress that it is in the national interest that consideration be given to geographical distribution of Federal research funds whenever feasible and that the National Aeronautics and Space Administration should explore ways and means of distributing its research and development funds whenever feasible.

Section 106

Section 106 would provide that the Act may be cited as the "National Aeronautics and Space Administration Authorization Act, 1983."

TITLE II

Title II provides authorization for the Secretary of Commerce to operate a civil land remote sensing space satellite system.

Section 201(a) authorizes the Secretary to provide for the management and operation of such a system, to provide for user fees, and to plan for the ownership and operation of such future systems by the private sector when in the national interest.

Section 201(b) authorizes $14,955,000 for fiscal year 1983 for the purpose of carrying out the provisions of this title.

COST AND BUDGET DATA

The bill will authorize appropriations for fiscal year 1983 in the amount of $6,662,300,000. In accordance with the requirements of Rule XIII, clause 7 of the Rules of the House of Representatives, the Committee's estimate for the next five years of the NASA budget request is as follows:

Fiscal year—	
1983	6,662,300,000
1984	6,522,400,000
1985	6,069,500,000
1986	5,517,300,000
1987	5,463,700,000

These estimates do not include provisions for any new program or program augmentation that may be recommended nor do they include any provisions for administrative adjustments that may be required.

EFFECT OF LEGISLATION ON INFLATION

In accordance with rule XI, clause 2(l)(4) of the Rules of the House of Representatives this legislation is assessed to have no adverse long-run inflationary effects and, in fact, to have positive economic benefits. NASA expenditures are labor intensive, with more than 80 percent of spending directly for jobs and the remainder for materials. NASA employs about 21,000 civil servants and supports about 107,000 contractor employees. Assuming a multiplier effect of 2.5, the total, short-run employment effect on the United States' economy is about 320,000 jobs. This represents less than one-half of one percent of the total civilian labor force in the United States—to small a number for NASA alone to have a significant national inflationary effect, although there could be some specific cases of industrial and regional employment and price changes influenced by NASA expenditures.

The most significant economic effects of NASA spending are the long-run economic growth from new technologies developed for the space and aeronautics programs. Many NASA-sponsored advances in air and space transportation communications satellites, remote sensing satellites, and other innovations have improved the productive capacity of industry and stimulated the development and growth of many new businesses. These expanded business opportunities have and are expected to continue to stimulate more productive, non-inflationary private sector economic growth and job creation.

Although it is difficult to assess the results of the various macroeconomic studies of the effects of NASA spending on GNP, it is apparent from analyses done by the Midwest Research Institute, Mathmatics, Inc., and others, that NASA high technology research and development expenditures have returned more to the economy in substantial and long-lasting productivity gains than has been spent. Therefore, we believe that NASA expenditures are non-inflationary and show positive economic returns in the long-run.

CHANGES IN EXISTING LAW MADE BY THE BILL, AS REPORTED

In compliance with clause 3 of Rule XIII of the Rules of the House of Representatives no changes in existing law are made by the bill, as reported.

OVERSIGHT FINDINGS AND RECOMMENDATIONS

Pursuant to clause 2(1)(3)(A), rule XI, and under the authority of rule X, clause 2(b)(1) and clause (3)(f), of the Rules of the House of Representatives the following findings and recommendations are under consideration by the Committee on Science and Technology:

[Excerpted from pages 1-2, NASA Space Communications Program Report, Serial S. February 1982]

FINDINGS AND RECOMMENDATIONS

FINDING NO. 1

No single private company can afford to finance the large capital outlays nor bear the high risks that broad-scale space communications R. & D. efforts require. This is not to say that private industry has not in the past and will not in the future engage in significant R. & D. Unlike NASA's R. & D., industrial research and development is product- or service-oriented. At this point in the development of 30/20 GHz technology, there appears to be too many technical uncertainties and too much financial risk for private industry to undertake a 30/20 GHz demonstration program.

FINDING NO. 2

NASA's space communications R. & D. has been successful. NASA's work from 1960 to 1973 provided the basic R. & D. on which low-risk commercial systems could be developed in the private sector. These commercial systems, in turn, provide services to millions of people throughout the world. Furthermore, the success of U.S. firms in the satellite communications industry have given the U.S. a strong lead in this important segment of business. This lead is now threatened by increased foreign competition.

FINDING NO. 3

The private sector should continue to be invited to participate in shaping the direction of NASA's work in 30/20 GHz R. & D. Participation by users in these experiments is essential in order to develop user acceptance and demand, and to demonstrate mission cost-effectiveness. Only such demonstrations can provide the commercial communications satellite industry with reasonable assurance of potential economic payoff and thus encourage the implementation operational service on a timely basis.

FINDING NO. 4

Without the continuation of a strong Federal R. & D. program, dominance by foreign countries of the strategic multi-billion dollar international communications satellite market of the 1990's is likely. The sale by U.S. manufacturers of $14 to $20 billion worth of satellite communications equipment has obvious balance of payments benefits. If the U.S. buys its 30/20 GHz equipment from abroad, then there could be an outflow of as much as $10 to $15 billion from the U.S. during the 1990 to 2000 period for equipment purchases.

Recommendation: The Federal Government should continue high-risk, long-term, and expensive R. & D. activities that will not likely be undertaken by private industry. Foreign competition in space communications is subsized by their respective governments, and the Federal Government should continue R. & D. activities to guarantee the U.S. a substantial portion of the future space communications market.

FINDING NO. 5

A private consortium of satellite carriers and builders to share the developmental costs of the 30/20 GHz R. & D. program is a possible alternative. Witnesses agreed that resolution of the many economic, corporate, and legal obstacles of such a consortium would be too involved and too lengthy a process to allow U.S. involvement in the technology development that would guarantee a 1986–88 flight demostration of 30/20 GHz technology.

Recommendation: The satellite carriers and builders consortium alternative should receive futher consideration by industry and the government for future space communications research and development activities.

[Excerpted from pages 1–4, Civil Land Remote Sensing System Report, Serial T, December 1981]

FINDINGS AND RECOMMENDATIONS

FINDING NO. 1

The United States has a preeminent position in remote sensing technology for monitoring and detecting earth resources and environmental quality which is a source of international responsibility as well as national pride.

FINDING NO. 2

As the innovator of global remote sensing technology the United States has an opportunity and an obligation to exploit this capability to promote more harmonious international relations and Third World development.

FINDING NO. 3

France, Japan, India, and European Space Agency are each involved in the development of space borne remote sensing systems with launches planned in the 1980's. Therefore, in the mid-1980's, the United States will no longer be the sole source of satellite remotely sensed data.

Recommendation: The United States should develop a foreign policy initiative to exploit our remote sensing capability to promote more harmonious international relations and Third World development. The National Aeronautics and Space Administration in coordination with the State Department should develop a long range plan that would optimize global capability to utilize satellite remote sensing data for consideration at the upcoming United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE-82).

FINDING NO. 4

The multi spectral scanner (MSS) instrument which has been carried on Landsats 1, 2, and 3 has been adequately demonstrated for deployment on an operational space system.

FINDING NO. 5

Landsat D is expected to demonstrate the technology for an operational land observing system. However additional spacecraft will be required to provide assurance of timely and uninterrupted service.

FINDING NO. 6

Elimination of funding for follow-on space hardware due to budget constraints has again threatened long-term data continuity, a major inhibition to market development.

FINDING NO. 7

Under current administration plans the United States earth remote sensing program will terminate when the last of two Landsat D satellites fail unless by then the private sector has taken over the program.

FINDING NO. 8

To date the most serious concept advanced by the private sector involves merging the weather satellite and land remote sensing satellites into a single system operated by a designated private sector entity.

Recommendation: The National Oceanic and Atmospheric Administration should carefully assess the feasibility of private sector operation of both the weather satellites and land remote sensing satellites and report findings to the Congress by August 31, 1982. Any selection of a designated private sector entity should be accomplished through a competitive process.

FINDING NO. 9

The management and technical requirements of an operational system can be met by a number of private organizations. One of the major unknowns confronting commercialization is the lack of market definition. Although the Government may represent 50 percent of the market, neither the actual size of the Government market, nor the technical requisites for compliance of Government needs have been defined.

Recommendation: A set of federally funded, competitive, detailed definition studies should be contracted to industry by the National Oceanic and Atmospheric Administration to define the technical, market, investment and operational aspects of a system that would meet government and private sector needs. The primary objective of each study would be to provide a realistic basis for the determination of optimum government and industry roles and a development schedule for an operational civil land remote sensing system.

FINDING NO. 10

Private sector ownership of a civil land remote sensing system would likely involve exclusive rights to the Government market and protection from competition for a period after selection. The value added segment of the market should be open to encourage new users, industries and market expansion. Copyright provisions will be necessary to protect both the operator and the additive value industry.

FINDING NO. 11

The current policy of non-discriminatory access to data creates a favorable climate for national and international data exchange.

Recommendation: The United States should continue the policy of open access to civil remote sensing data and continue to encourage international exchange and assistance.

FINDING NO. 12

Many of the operational guidelines for a private sector operator could be written into a contractural agreement. The framework should include: (1) protection from competition for a period after selection, (2) compliance with U.S. foreign policy and security requirements, (3) minimum performance standard for raw data, (4) nondiscriminatory access to data, (5) assurance of fair pricing policies and (6) a performance review process.

FINDING NO. 13

Since the Federal Government may represent approximately half of the initial market base of any private operation, significant influence on pricing policy by Government and promulgation of regulations or specifications will be inevitable.

FINDING NO. 14

Government should continue high risk research and development on next-generation components and systems after the commercialization of current generation remote sensing technology occurs.

FINDING NO. 15

Government/industry joint ventures represent an institutional mechanism which should receive further consideration for the transition of financial responsibility for land observing systems from the Government to the private sector.

FINDING NO. 16

Government should recover a larger share of Landsat costs, but this should be done in steps and with caution to encourage market expansion and growth of users. Research and development costs should be considered as sunk costs and should not be amortized.

FINDING NO. 17

State and federal agencies make extensive use of Landsat data for resource inventories, monitoring and planning. Fifteen states have routine operational capabilities to use Landsat data; state use of Landsat data has grown 61 percent since 1978. States are more concerned that data be continuously provided at a fair price than with who operates the system.

Recommendation: Long-lead data pricing schedules should be provided to enable state governments to adjust their legislative budgets in order to alleviate adverse impacts on state programs.

FINDING NO. 18

Universities continue to be a major contributor in remote sensing research and training activities which are important in expanding the use of this complex technology. University research and training will be inhibited by significant cost increases for data.

FINDING NO. 19

In a historical perspective the premier policy decisions that have had a positive effect on the development of civil land remote sensing technology have been: (1) long-range development of research and development beginning in the early 1970's, and (2) non-discriminatory international dissemination of data.

FINDING NO. 20

The greatest negative influence on the evolution of an operational civil land remote sensing system has been the inability to fully evaluate the relationship between Landsat and national needs and to provide a long-range policy that is continuously reflected in the budget.

CONGRESSIONAL BUDGET ACT INFORMATION

This bill provides for new authorization rather than new budget authority and consequently the provisions of section 308(a) of the Congressional Budget Act of 1974 are not applicable. No authorization for State or local financial assistance is included in the bill.

ESTIMATE AND COMPARISON, CONGRESSIONAL BUDGET OFFICE

Pursuant to clause (2)(l)(3)(C) of rule XI of the Rules of the House of Representatives the report of the Congressional Budget Office is included.

CONGRESSIONAL BUDGET OFFICE—COST ESTIMATE

MAY 5, 1982.

1. Bill number: H.R. 5890.

2. Bill title: National Aeronautics and Space Administration Authorization Act, 1983.

3. Bill status: As ordered reported by the House Committee on Science and Technology, April 28, 1982.

4. Bill purpose: The bill authorizes the appropriation to the National Aeronautics and Space Administration (NASA) of $6,647 million for fiscal year 1983: $5,378 million for research and development, $100 million for construction of facilities, and $1,169 million for research and program management. The authorization for research and development includes $1,706 million for the space shuttle, $1,699 million for space flight operations, $464 million for physics and astronomy, $330 million for space applications, $267 million for aeronautical research, and $499 million for tracking and data acquisition. The bill also authorizes such additional amounts as may be necessary for increases in salary, pay, retirement, or other employee benefits.

The amounts authorized exceed the President's request of $6,613 million for NASA in fiscal year 1983 by $34 million, and are $707 million above fiscal year 1982 appropriations to date for NASA.

In addition, title II of the bill authorizes an appropriation of $15 million for fiscal year 1983 for the management and operation of a civil land remote sensing space satellite system, including the LANDSAT D and D' satellite systems, transferred from NASA to the Department of Commerce. The title also authorizes the Department to recover its costs through the imposition of user fees and to plan for the ownership and operation of future civil remote sensing systems by the private sector, which must be approved by both the House Committee on Science and Technology and the Senate Committee on Commerce, Science, and Transportation.

5. Cost estimate:

[By fiscal years, in millions of dollars]

	1983	1984	1985	1986	1987
Estimated authorization level:					
NASA—Civilian space program (Function 250)	6,380				
NASA—Aeronautics (Function 400)	267				
NASA—Allowance for pay increase (Function 920)	55				
Department of Commerce (Function 300)	15				
Offsetting receipts (Function 300)	−15				
Total	6,702				
Estimated outlays:					
NASA—Civilian space program (Function 250)	4,675	1,468	223	12	2
NASA—Aeronautics (Function 400)	249	12	6		
NASA—Allowance for pay increase (Function 920)	52	3			
Department of Commerce (Function 300)	15				
Offsetting receipts (Function 300)	−15				
Total	4,976	1,483	229	12	2

6. Basis of estimate: The estimate assumes that the full amounts authorized will be appropriated prior to the beginning of fiscal year 1983. The increase in salaries and benefits was estimated at 6.74 percent of the personnel compensation provided by the authorization. CBO estimates that an additional $55 million will be necessary for this increase. CBO also assumes that the National Oceanic and Atmospheric Administration will recover all of the costs associated with the civil land remote sensing system. Estimated annual outlays are based on historical spending patterns of the major NASA programs.

7. Estimate comparison: None.

8. Previous CBO estimate: None.

OVERSIGHT FINDINGS AND RECOMMENDATIONS, COMMITTEE ON GOVERNMENT OPERATIONS

No findings or recommendations on oversight activity pursuant to clause 2(b)(2), rule X, and clause 2(1)(3)(D), rule XI, of the Rules of the House of Representatives have been submitted by the Committee on Government Operations for inclusion in this report.

COMMITTEE RECOMMENDATIONS

A quorum being present, the Committee approved the bill by voice vote.

NASA RECOMMENDATIONS

This is a National Aeronautics and Space Administration legislation item approved with the exceptions noted in this report by the Office of Management and Budget, as indicated by the following letters:

National Aeronautics and Space Administration,
Office of the Administrator,
Washington, D.C., February 9, 1982.

Hon. Thomas P. O'Neill, Jr.,
Speaker of the House of Representatives,
Washington, D.C.

Dear Mr. Speaker: Submitted herewith is a draft of a bill, "To authorize appropriations to the National Aeronautics and Space Administration for research and development, construction of facilities, and research and program management, and for other purposes," together with the sectional analysis thereof. It is submitted to the Speaker of the House of Representatives pursuant to Rule XL of the House.

Section 4 of the Act of June 15, 1959, 73 Stat. 75 (42 U.S.C. 2460), provides that no appropriation may be made to the National Aeronautics and Space Administration unless previously authorized by legislation. It is a purpose of the enclosed bill to provide such requisite authorization in the amounts and for the purposes recommended by the President in the Budget of the United States Government for fiscal year 1983. For that fiscal year, the bill would authorize appropriations totaling $6,612,900,000, to be made to the National Aeronautics and Space Administration as follows:

(1) for "Research and development" amounts totaling $5,334,000,000;

(2) for "Construction of facilities" amounts totaling $100,000,000; and

(3) for "Research and program management," $1,178,900,000.

In addition, the bill would authorize such sums as may be necessary for fiscal year 1984, i.e., to be available October 1, 1983.

The enclosed draft bill follows generally the format of the National Aeronautics and Space Administration Authorization Act, 1982 (Public Law 97-96). However, the bill differs in substance from the prior Act in several respects.

First, subsections 1(a), 1(b), and 1(c), which would provide the authorization to appropriate for the three NASA appropriations, differ in the dollar amounts and/or the line items for which authorization to appropriate is requested.

Second, section 6 of Public Law 97-96, which added a new paragraph (6) to section 7 of title 18, United States Code, has been omitted since the amendment is now permanent law.

Third, section 7 of Public Law 97-96, which added new subsections (k) and (l) to section 305 of the National Aeronautics and Space Act of 1958, as amended, has been omitted since the amendment is now permanent law.

Fourth, section 8 of Public Law 97-96, which repealed section 6 of the National Aeronautics and Space Administration Authorization Act, 1970, as amended (42 U.S.C. 2462), has been omitted.

Fifth, section 9 of Public Law 97-96, which dealt with a one-time requirement for an assessment and report concerning Space Transportation System Upper Stages, has been omitted since the report was submitted to the appropriate Congressional committees.

Sixth, in addition to providing authorization of appropriations in the amounts recommended by the President in his Budget for fiscal year 1983, the bill also would provide authorization for such sums as may be necessary for fiscal year 1984. It is specified that all of the limitations and other provisions of the bill applicable to amounts appropriated pursuant to section 1 shall apply in the same manner to amounts appropriated pursuant to section 6.

Finally, the last section of the draft bill, section 7, has been changed to provide that the bill, upon enactment, may be cited as the "National Aeronautics and Space Administration Authorization Act, 1983," rather than "1982."

Where required by section 102(2)(C) of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4332(2)(C)), and the implementing regulations of the Council on Environmental Quality, environmental impact statements covering NASA installations and the programs to be funded pursuant to this bill have been or will be furnished to the Committee on Science and Technology as appropriate.

The National Aeronautics and Space Administration recommends that the enclosed draft bill be enacted. The Office of Management and Budget has advised that such enactment would be in accord with the program of the President.

Sincerely,

JAMES M. BEGGS,
Administator.

ADDITIONAL VIEWS OF CONGRESSMAN GEORGE E. BROWN, JR. ON THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION FY '83 AUTHORIZATION

Our deliberations on the FY '83 NASA authorization have been greatly limited by the absence of a coherent national space policy. This has come about because of the Committee's desire to stay within the Administration's arbitrarily constrained budget. The lack of a space policy, coupled with a limited budget results in a kind of haphazard program.

Congress, in the past, has generally played the limited role of reacting to White House initiatives in the development of space policy and programs. However, there seems to be no indication of vigorous Executive leadership at this time, and it appears unlikely to develop. With the ebbing of the forces generated by the launching of Sputnik, and the successful completion of the resulting Apollo program, our space policy is presently in disarray. Clearly if our space programs are to endure, we must direct our attention toward rearticulation of a national space policy. If we do not direct attention to this need, we will slowly erode our science and technology base in space and ultimately threaten the goal of economic recovery which we all want.

At first glance, the NASA budget seems to fare well under this Administration. However, when the increases in the shuttle program are taken into account, most other programs have suffered cuts. Of particular note is the planetary program. I commend the Committee for adding funding back to the planetary program, but even with the addition, the program is only funded at its FY '81 operating level. No 'new starts' are planned in the planetary program and we have yet to receive concrete proposals from the Administration on its plans for restoring a vigorous planetary exploration program.

The refusal by the Committee to support the Solar Maximum Mission is just one example of the lack of leadership from the Administration in support of an important program. The Committee disagreed on priorities, while agreeing to the overall budget. Some programs had to be hurt under these constraints. Casual observers may note the spectacular missions conducted by this nation, but I would only indicate the lack of an aggressive plan for exploration of the solar system in the future.

I would like to comment along these same lines on the 'flip-flop' of the Committee on the question of an upper stage for future launches. The arguments for various stages have been made before, and I will not go into them here. I would only like to point out that here again we have an example of how the absence of a space policy, and therefore of a coherent program, has led to confusion of our needs for an upper stage. We need to know what we want to do in order to know what technology we need to develop and we need to know in a timely fashion.

Finally, I am equally disturbed by the lack of an aggressive stance taken by the Committee on the LANDSAT program. The Administration would like to see a transfer to the private sector, but does not know how it can be done. The result of this on our Committee consideration of the issue is a feeble attempt to retain some control of the situation without doing what is necessary to address the serious problems and questions. We are essentially 'treading water' on this issue as on most of or space programs as we await policy directives.

We are in difficult budgetary times. The answer in times such as these is to look very hard at our policies. With these clearly in mind we can decide the best course of action to achieve the economic recovery and progress which we all want.

George E. Brown, Jr.

ADDITIONAL VIEWS OF HON. DAN GLICKMAN

The Science and Technology Committee has proposed a FY 1983 budget of $267.1 million for NASA Aeronautical research and technology. While that is a $35.1 million increase over the Administration's proposal of $232 million, it is still well below the FY 1982 authorization and below the FY 1982 appropriation of $270.6 million. In fact, the Committee proposal reflects the continuing trend of decreased government support for aeronautics research from the 1980 expenditure of $308 million.

The NASA Aeronautical Research and Technology program is exceptionally well managed and uniquely effective in getting advanced technology into practical commercial use. It is probably the most effective technology transfer organization in the world.

In spite of this, in my judgment, the Administration seems intent on taking the first "A" out of NASA. This year, the Committee was faced with a budget proposal that sought to eliminate all of NASA's ongoing aeronautical technology validation work, except work in areas that had clear military application and support. The civil systems technology projects targeted for termination included many vital, high-risk, "next-generation" technologies that industry is simply unable to undertake alone, such as the Advanced Turboprop, Energy Efficient Engine, Advanced Rotorcraft, Composite Primary Aircraft Structures, Terminal Configured Vehicle, Energy Efficient Transport, and other programs. The Committee could not accept such a radical departure from the traditional role that NASA (and NACA) have utilized successfully for more than 65 years in supporting civil aeronautics research and technology. I strongly endorse the Committee's decision to restore the funding necessary to complete the most critical of these programs.

The NASA Aeronautics program is small, accounting for only 10% of NASA's total budget. But its impact reaches to the very core of our national security and economic well being. The U.S. aeronautics industry is a $60 billion business, providing a $35 billion payroll, and employing 1.25 million Americans. It is by far our largest source of manufactured exports, with $18 billion in shipments during 1981, of which only $4 billion were military.

The historical superiority of the U.S. aeronautics industry is no accident. It is the direct result of an outstandingly effective partnership between government and industry which began in 1915 with the creation of the National Advisory Committee for Aeronautics (NACA) and continued when NACA was assimilated into NASA. The purpose of this partnership was to maintain the role of the U.S.A. as a leader in aeronautical science and technology.

For the first time, however, as government is decreasing its support for aeronautics research, America's leadership in aviation is being seriously challenged. The projected 2% decline in exports for 1982 marks the first year-to-year decrease in history for the U.S.

aerospace industry. General aviation exports declined by 36% in 1981, while imports of foreign aircraft increased by 23%. Perhaps the most astonishing example is Europe's government supported civil transport consortium, Airbus Industrie, which sold more wide bodied aircraft last year (64) than all U.S. suppliers combined (43). This is a far different situation than the historic 90% share of the world market that the U.S. used to enjoy.

The message is clear. The U.S. aviation industry is—not might, but already is—going the way of the U.S. auto industry. The key issue is jobs. When we allow our technological superiority to slip away, we are exporting American jobs to Europe, Japan, Brazil, and other areas of the world. The U.S. aviation industry has already been forced to lay-off thousands of employees. This week it was announced that 10,000 more aircraft workers will lose their jobs this year.

Now is not the time to experiment with one of our few remaining economic winners. We have a system that works. We should support it. We must not be misguided by dogmatic theorists who have no understanding of the historic importance of government's role in the success of U.S. aeronautics. We cannot afford to tinker with a system that has proven, time and time again, to be a high-payoff cost-effective investment for America's future.

DAN GLICKMAN.

ADDITIONAL VIEW OF HAROLD C. HOLLENBECK, RAYMOND J. MCGRATH, AND BILL LOWERY

An issue which has been of concern to several Committee Members is the selection by NASA of an upper stage for the Space Shuttle. In FY '81 NASA planned to fly the Galileo and Solar/Polar Mission with one type of launch vehicle. In FY '82 that planning changed for technical reasons. In FY '83 planning was changed for fiscal reasons to the vehicle that had been deleted in FY '82 for technical reasons. The year to year inconsistency of budget submissions for a Shuttle upper stage for these missions and for future use is deeply disturbing.

Last year our Subcommittee Chairman had the foresight to request that NASA and DoD study this matter thoroughly. Subsequent to the completion of "upper stage alternatives" report, we are concerned that NASA is not adhering to its own recommendations.

It is our desire that NASA proceed along a course that is technically appropriate. It is similarly our desire that the development of a high energy upper stage for the Shuttle be carried out without spending an extraordinary amount of federal money while developing a stage that will maximize the capability of the Shuttle as soon as possible.

Such an approach may avert the necessity for the protracted debate that should not be necessary at all.

Harold C. Hollenbeck.
Raymond J. McGrath.
Bill Lowery.

ADDITIONAL VIEW OF RAYMOND J. McGRATH

During the Subcommittee mark-up of the 1983 NASA Authorization, I raised the issue of New York State's interest in NASA's State Technology Applications Program.

NASA's State Technology Applications Centers (STACs) were established to investigate the viability of decentralizing the functions performed by the Industrial Applications Centers on a regional basis to the state and local level. This approach utilizes the relationships between state universities and local industry and government to assist in the technology transfer process. There are currently two STACs—one in Florida and the other in Kentucky. Both STACs have proven very successful in providing beneficial assistance to their clients. Key to their success is a strong commitment by their respective state governments. Last year, the NASA STACs experienced a client growth rate of approximately 45 percent over the previous year.

The State of New York has taken a number of important steps in recent years to foster the growth of technologically innovative firms in our state. This year, the State Legislature is considering several additional proposals for significant investments of state funds in various types of university-based centers for research and development of new technologies. Because of the importance of the dissemination of research findings to businesses facing particularly challenging problems or opportunities, New York is very interested in the establishment of a Technology Application Center in our State.

I would like to take this opportunity to encourage NASA to consider establishing a STAC in New York State. I sincerely believe NASA's commitment to acquiring and disseminating to the public technology and information developed in the Space Program would be enhanced by the location of a State Technology Application Center in New York State.

RAYMOND J. MCGRATH.

ADDITIONAL VIEW OF MR. LOWERY

I take exception to this committee's action on the proposed revisions of NASA's space transportation upper stages program and related changes in the Galileo mission to Jupiter and the International Solar Polar Mission (ISPM).

Last year, after reviewing the NASA FY 1982 budget request to develop a modified Centaur to support planetary exploration programs, this committee directed that NASA and the DOD conduct a joint study to determine our nation's upper stage requirements and to define the most appropriate program for meeting these needs. Both agencies proceeded to examine current and projected mission requirements and evaluated the following upper stages against those requirements: Inertial Upper Stage (IUS), Centaur, Transtage, Interim Orbital Transfer Vehicle (IOTV).

The agencies concluded that the IUS is the only available stage capable of meeting the near term earth-orbiting requirements and, with modifications, could satisfy NASA and DOD earth-orbiting missions through the 1980's. However, the study clearly indicated that the Centaur is the only vehicle capable of meeting near term NASA planetary requirements, particularly the need for a Galileo combined Orbiter/Probe mission on a direct trajectory to Jupiter. Additionally, it was determined that the Centaur will satisfy the future envisioned and proposed NASA planetary missions through the mid-1990's.

Such findings led NASA and the DOD to recommend that the Air Force continue IUS development and production while NASA begin developing the Centaur. In the intervening four months since this report was released, nothing has significantly changed to warrant reprogramming monies from Centaur to IUS in the NASA budget.

In fact, an IUS/Galileo mission, utilizing the IUS on a delta-Vega trajectory, was specifically rejected by the joint study:

> . . . an IUS Galileo . . . on a delta-Vega trajectory (provides), at best, major compromise to the mission . . . In addition to mission deficiencies, the combination of weight and CG location for a Galileo combined spacecraft with kick stage would represent a load to the generic IUS which is greater than design limits. This fact would require, as a minimum, structural modifications to stiffen that upper stage . . . While it is apparent that a mission with a combined Galileo spacecraft can be accomplished with upper stage performance characteristics equivalent to an IUS, it is not clear that such a mission could be accomplished without major science compromises as well as high cost and schedule risks which would make a single launch in 1985 undesirable . . .

Because this committee's decision to cancel Centaur has very serious ramifications on our civilian space program, not to mention our defense, intelligence, and telecommunications capabilities, I believe it is necessary to reiterate the compelling reasons for proceeding with Centaur development for Galileo:

IUS cannot meet high energy upper stage requirements for NASA, DOD, and commercial missions;

Failure to move decisively now to develop a high energy upper stage for Shuttle will result in an increasing loss of business to foreign competition;

Development of a "new" high energy upper stage, coupled with the decision to reprogram IUS for Galileo, will cost at least $700-800 million more than Centaur, take at least two years longer to complete, and yield no significant performance improvement;

Launching Galileo on Centaur in 1986 has two critical advantages over a 1985 IUS/Galileo mission: cost and benefit.

First, IUS cannot meet high energy upper stage requirements for NASA, DOD, and commercial missions. IUS has a basic design capability of 5,000 pounds to geosynchronous orbit compared to 10,000-13,000 pounds for Centaur (depending on which Centaur configuration is utilized). Consequently, as lift requirements increase, the need for an adequate upper stage intensifies. Again, the joint NASA/DOD study accurately summarized this issue:

> The collective trends illustrated as a result of the current analysis of earth-orbiting payload requirements show that in the late 80's, a need will exist to deliver payloads greater than 5,000 pounds into geosynchronous orbits and that the existing vehicles of the 1980's will determine the spacecraft designs of the late 1980's and the early 1990's. The results also indicate that geosynchronous spacecraft development/growth rate was slowed considerably during the last decade. Should a higher performance vehicle become available at affordable per flight cost, by 1985, spacecraft requirements will grow and effectively utilize the carrier capability in the late 1980's.

Second, failure to move decisively now to develop a high energy upper stage for Shuttle will result in an increasing loss of business to foreign competition. Unquestionably, launches for foreign payloads, mainly communications satellites, yield a large, favorable balance of payment to the United States. It is almost an assurance that the failure to continue Centaur development for the Shuttle will open this launch market to the Europeans and Japanese.

INTELSAT and COMSAT have indicated that commercial payload developers desire spacecraft with lift capacities which far exceed existing carrier capability. According to the joint study, INTELSAT would probably plan earlier conversion to Shuttle capability of Centaur proceeded through development.

Significantly, the Direct Broadcast Satellite Corporation, in a recent letter to this committee, stated that as a practical matter, the IUS will not be used for commercial space programs because of its cost and lack of flexibility. The letter goes on to say that what is clearly needed is a flexible, high-performance, and reasonably priced upper stage of the kind we thought we had in the Centaur program until the funds for it were recently suspended.

Third, development of a "new" high energy upper stage, coupled with the decision to reprogram IUS for Galileo, will cost at least $700–800 million more than Centaur, take at least two years longer to complete, and yield no significant performance improvement. Furthermore, a new development, as conceived by this committee, would not approach the maturity and reliability of Centaur for at least several years of operation. Recall that Centaur has flown 66 times and has achieved 100% reliability over the last 10 years (40 consecutive successful launches).

Experience suggests that a competitive new development program, while appealing on the surface, is not as cost effective or beneficial as the evolutionary method of upgrading systems. Specific examples in the NASA launch vehicle program include: (1) Centaur integration with the Titan launch vehicle; (2) the many upgrades of the Delta vehicle; (3) the evolution of the Saturn F IVB stage into the Skylab program. Accordingly, the evolution of Centaur into the Space Shuttle would capitalize on the $3 billion of U.S. taxpayer investment in the Centaur program, spanning the last 20 years.

Fourth, launching Galileo on Centaur in 1986 has two critical advantages over a 1985 IUS/Galileo mission: cost and benefit. Although launched one year later, Centaur/Galileo will arrive at Jupiter in 1988, nineteen months earlier than the arrival of the '85 IUS/Galileo. This substantial delay will add an additional $120 million to the mission.

Also, Centaur will not compromise the scientific value of the Galileo mission. In comparison, IUS will only provide enough energy to complete 6–8 Jovian encounters instead of the 11 planned with a high energy upper stage.

In addition to the above factors supporting a Centaur development program, I would like to address two major concerns surrounding this debate: cost comparisons and sole-source procurement.

To this date, I have not seen accurate, reliable and meaningful cost comparisons for IUS, Centaur, and a new high energy upper stage. Even as we marked up NASA's authorizations, the agency continued to send mixed signals as to various costs associated with upper stage development. Needless to say, I am appalled at both NASA and DOD conduct in this regard, and hope that such action can be avoided in the future.

Importantly, the costs associated with Centaur and IUS for Galileo, whatever they actually are, are not significantly different enough to justify one vehicle over the other. Simply stated, the cost issue is a wash. What is not so simple is the added factor of developing a "new" high energy upper statge, in lieu of Centaur, while proceeding with IUS for Galileo and ISPM. Clearly, the costs associated with such a decision are not a wash, but tilt strongly in favor of continuing Centaur development. In fact, by approving NASA's reprogramming to IUS for Galileo, this committee has tacitly embraced an unnecessary federal expenditure of $750 million over the next 5–6 years. Thus, I consider this reprogramming and subsequent decision to "compete" a new stage to be imprudent and impractical.

Finally, NASA can convincingly justify a sole-source procurement for Centaur, despite a 1986 Galileo launch date and vociferous protests. Sole-source procurements are authorized under 10 U.S.C. 2304(a)(10) and NASA Procurement Regulation 3-210.

Because of the requirement for maximum practical competition in the conduct of Government procurements, agency decisions to procure sole-source must be adequately justified and are subject to close scrutiny. However, the General Accounting Office (GAO) will not substitute its judgment for that of NASA when reviewing the justification for a sole-source porocurement, but will only determine whether the agency decision has a reasonable basis. Hence, the burden is on the protester to make a clear showing that NASA's decision is unreasonable.

As we learned last year, "time-is-of-the-essence" is a circumstance that alone may justify a sole-source award. The timing for the launch of a space mission is clearly within NASA's discretion and the GAO has held that mere disagreement with a contracting agency's discretionary decision is not grounds to disturb it. To be sure, if Galileo and ISPM are to use a high energy upper stage, time is of the essence.

Alternatively, I would point out that Centaur design, production, and launch operations teams are now at work on continuing orders extending through 1984. NASA management and support staffs are also functioning. Tools and equipment for production, testing, and launch support exist now in mature form.

Centaur for the Shuttle has been studied by three NASA Centers and various contractors. Safety aspects have undergone particularly close scrutiny again over the last several years. Consequently, sole-source procurement of the Centaur would take advantage of this wealth of hardware and experience.

Moreover, the development of Centaur would, in fact, initiate a more meaningful competition within the Shuttle's upper stage program. By allowing Centaur to compete with IUS for Shuttle launches, just as the Atlas/Centaur now competes with the Ariane, we would be promoting significant cost de-escalations. Accordingly, the question is not "competition or no competition," but "development competition or production competition." Incisively, a production competition, focusing on price and performance, is in the best interests of the American taxpayer and our civilian space program.

In sum, developing a new high performance stage would unquestionably take longer than modifying an existing stage. To run a full competition, as contemplated by this committee, would also delay the availability of a high performance stage. A new stage also would not approach the maturity and reliability of a modified Centaur and, undoubtedly, costs would be much higher than for a modified Centaur.

I strongly urge my House and Senate colleagues to pursue Centaur development in the NASA FY 1982 and 1983 budgets for a 1986 Galileo launch.

Bill Lowery.

ADDITIONAL VIEW OF JOE SKEEN

These views are presented to underscore our strong support for the Solar Maximum Mission (SMM) as a key element in demonstrating the shuttle's unique capability to retrieve and either repair or refurbish an orbiting spacecraft or return it to earth.

The Space Science and Applications Subcommittee's rejection of NASA's proposed reprogramming of fiscal 1982 funds clearly result in the loss of valuable scientific and technological information required for planning and executing future flights, particularly the space telescope maintenance and upgrading missions, where this capability is an essential part of the planned long-term use of the research capability of the spacecraft. Other users await more evidence that in-orbit repair and maintenance is a cost-effective alternative to launching replacement spacecraft when the spacecraft in orbit experiences a malfunction or needs a Solar Maximum Mission spacecraft specifically designed for on-orbit repair, is so feasible. Replacement of the spacecraft's attitude control system and repair of three instruments will restore the solar maximum spacecraft to full operational status. This will permit continuation of solar observations of considerable importance to the scientific community and the understanding of the earth's environment.

In addition to the benefits mentioned above, this mission now offers the opportunity to gather very specific radar and optical data to confirm the tumble rates and breakup characteristics for the STS external tanks as it re-enters the atmosphere. Previous plans to gather this data involved expensive deployment of a special tracking ship to the Indian Ocean. The special orbit for this mission allows the external tank re-entry to occur at a safe distance from the Hawaiian Islands but within tracking range of radar and optical sensors located there. Therefore, the mission as now planned offers multiple benefits, including that of refining the external tank re-entry model, which should offer safer and more flexible future shuttle orbital planning.

JOE SKEEN.

ADDITIONAL VIEWS OF HON. JIM DUNN

I am opposed to the action taken on the fiscal year 1983 budget. First, the Minority recommended that the total NASA R&D budget remain at the Reagan level of $6.613 billion, which represented an approximate 11% increase over the fiscal year 1982 budget. In addition, I also opposed the distribution of the budget amongst the various line items.

Specifically, while I advocate enhancements to the proposed budget, I feel that any increases to the aeronautics authorization should come from the space program budget. The Administration's policy shift away from system development and toward greater basic aeronautical research activities is reflected by the 12% increase in the "Research and Technology Base" budget. The further enhancement of $6 million by the Committee to the basic research program is not justified in view of the fact that the majority of this increase is aimed at accelerating existing activities in materials ($2M), human factors ($1M), aerodynamics ($1.5M) and multidisciplinary research ($1.5M) items already sufficiently funded in the Administration's Research and Technology base program at $31.3M, $9.6M, $42.3M and $3.5M, respectively.

I also disagree with the Committee recommendation in the "Low Speed Aircraft System Technology" line item. I recognize and accept the importance of this technology work, and under other circumstances would undoubtedly support such enhancements. Because of the serious budget constraints, however, I do not believe that the increases are warranted. The Administration's action to move the critical technology elements of the advanced rotorcraft program into the research and technology base is adequate at this time. In addition, much of the technology to be derived from the remaining NASA/military helicopter projects has direct application to the civil aeronautics field.

Similarly, a third area of disagreement is the "High Speed Aircraft Systems Technology" line item. The most important elements of the turbine engine activities continue under the Administration's budget. In addition, related work is also incorporated into the research and technology base budget. The argument was made by the Majority that aeronautics research is dominated by the military at the expense of the civilian is not a sound argument. In the first place NASA is directed in section 102 of the National Aeronautics and Space Act of 1958 to conduct research specifically aimed at maintaining the "general welfare and security" of the United States. Secondly, and more importantly, the research being conducted is basic generic research which has application to both civilian and military systems. Therefore, I would argue that it is not possible to discriminate between the two. The NASA/military relationship has been a long established arrangement with NASA funding approximately 60 percent of joint projects. There are no plans by the military to increase their aeronautical research budget. Further, I feel that failure to provide sufficient basic research support of military aeronautical R&D could create serious strategic capability problems in the future.

I share the Committee's concern with the need for greater emphasis on high risk technology for civil aviation applications, but disagree with the Committee's recommended levels of enhancement for specific projects. The Committee levels assume an appropriation increase to the fiscal year 1982 budget. In contrast, I suggest enhanced civil aviation levels for the Energy Efficient Transport, Composite Primary Aircraft Structures, and Advanced Turboprop projects based on existing FY 1982 funding levels; my recommended levels would provide adequate funding to continue research on these projects in a timely and orderly manner.

Jim Dunn.

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